LA-14066-H
History

Tracing the Origins of the W76: 1966–Spring 1973 (U)

Betty L. Perkins

November 3, 2003

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TRACING THE ORIGINS OF THE W76: 1966–SPRING 1973

by

Betty L. Perkins

ABSTRACT (SRD)

The objective in writing this report was to place the development of the W76, before it entered Phase 3, in a historical perspective. The author has rather arbitrarily chosen to consider for this pre-Phase 3 history, the history of the weapon program at Los Alamos during the years 1966–May 1973.

The report tries to provide some understanding as to why, in the spring of 1973, the Los Alamos Scientific Laboratory received the Phase 3 assignment and why the assignment was important to the future of Los Alamos. In addition, the report provides insight into why historically the design of the W76 evolved as it did.

Chapter I provides general information including the organization of the Laboratory during the time-period of interest and the definition of what is included in the different phases in weapon development.

Chapter II discusses the work on primary design.

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Chapter IV briefly describes the early development effort for several of the materials that would be important in the W76 program.

(b)(3) The engineering status of several ancillary components such as detonators and gas storage systems is reported. Chapter IV notes the vulnerability tests relevant to the early LASL XW76 weapon program.

Chapter V includes a brief discussion of the history of the weapon systems assigned to Los Alamos as Phase 3 programs during the 1966–spring 1973 period. The extensive effort that was required for the various Phase 1 and 2 programs and the early advanced development programs under consideration during these years is also discussed. It is noted that despite this effort, the Los Alamos weapon teams failed during 1966–1972 to win a viable Phase 3 assignment to develop a warhead for a strategic missile weapon system. The chapter also includes some trends in the U.S. nuclear stockpile that are important in understanding the 1970–1980s weapon programs.

Chapter VI outlines the Los Alamos effort for the Mk 18 and the later Mk 400 programs; programs that served as the precursor programs to the W76. This chapter provides insight on the Los Alamos effort to obtain a Phase 3 assignment for a strategic warhead and the success in this effort that resulted in the long desired award of the XW76 program to Los Alamos.

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CHAPTER I. INTRODUCTION

A. Explanation

1. Assignment

The assignment given to the author was to outline the history of the development of the W76 warhead (presently carried on both the Navy's Trident C4 and D5 submarine-launched ballistic missiles). Because the Los Alamos Scientific Laboratory [LASL] received the Phase 3 assignment for this warhead in the spring of 1973, it would be reasonable to assume that a history of the W76 would cover only the period from the Phase 3 assignment until the initial operational capability of the W76 was achieved in October 1979 (Poseidon back-fit). But history is continuous. What happens at one point in time is dependent upon what happened earlier.

In order to set the development of the W76 in the necessary perspective, give some understanding as to why in the spring of 1973 LASL received the Phase 3 assignment and why the assignment was important to the future of Los Alamos, and indicate several reasons why the design of this device evolved as it did, a history of work prior to 1973 is required. The author has rather arbitrarily chosen to consider for this history, the history of the weapons program at Los Alamos during the years 1966–May 1973. (However, to give continuity, some aspects of the program are also described for work completed before 1966.) This pre-Phase 3 effort at Los Alamos is the focus of this report.

However, the author must insert a warning to the reader. It must be noted that to further increase the complexity that is history, it is almost impossible to identify all the factors that go into determining actions during a specific era. In addition, the description of an event is dependent upon the available "data set" of historical documents. Moreover, how an event is described in a point in time is dependent on what happens later and on our own personal experiences, knowledge, and "mindset." Thus, no history can be completely objective.

2. Overview

Before the award of the design effort for the W76 to Los Alamos, the U.S. nuclear weapon designers had been required—by the introduction of MIRVed (Multiple Independently Targeted Reentry Vehicle) missiles into the U.S. weapon arsenal—to develop lightweight/small warheads for use in the missiles' reentry vehicles.

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Chapter IV will briefly describe the early development effort for several of the materials that would be important in the W76 program.

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The engineering status of several ancillary components such as detonators and gas supply systems will be reported. Chapter IV will also note the vulnerability tests relevant to the LASL XW76 weapon program.

Chapter V will outline and briefly discuss the history of the weapon systems assigned to Los Alamos as Phase 3 programs during the 1966–1972 period. In addition, mention will be made of Phase 1 and 2 programs and early development programs under consideration during those years. This chapter will attempt to inform the reader as to the extensive effort that was required. However, as Chapter V will also describe, the Los Alamos weapon teams failed during 1966-1972 to win a viable Phase 3 assignment to develop a warhead for a strategic missile weapon system. The W62 for the Minuteman III with a Phase 3 of 1964 went to Livermore. The W68 for the Navy's Poseidon submarine with a Phase 3 of 1966 also went to Livermore. Earlier, the W56 (the warhead for the Minuteman I, II) and the W58 (the warhead for the Navy's Polaris) had also gone to Livermore. The Chapter will also note some trends in the U.S. nuclear stockpile that were important for the weapon programs at the Livermore, Sandia, and Los Alamos laboratories.

Although the program was finally canceled, of particular importance to the later W76 development was the Mk 18 program. This program will be covered in some detail in Chapter VI. The Navy's Mk 400 program was the precursor program to the W76. The history of the Mk 400 program will also be outlined in Chapter VI. This chapter will discuss the vital question: who would win the Phase 3 for the Mk 400 (XW76) Los Alamos or Livermore?

B. Los Alamos Scientific Laboratory Management Structure and Philosophy

1. Norris Bradbury

Norris Bradbury served as the director of the Laboratory at Los Alamos from October 1945 until September 1970. When he accepted this job and became director in October 1945 just after the end of WWII, he promised that he would serve for six months. But the six months of service stretched into twenty-five years.

In a January 1967 letter to Charles Winter, Deputy Director of the Division of Military Application, Bradbury described the Laboratory, "Los Alamos is organized on a facility and technology basis; LRL is organized more on a project basis." Bradbury also noted, "Internally in the Laboratory, the weapon program is steered by a committee chaired by the Laboratory Director and comprised of Assistant Directors and relevant Division Leaders. Basic decisions are made by this group, the members of which carry the authority within their respective areas of responsibility to implement them. More detailed discussions and decisions within the framework

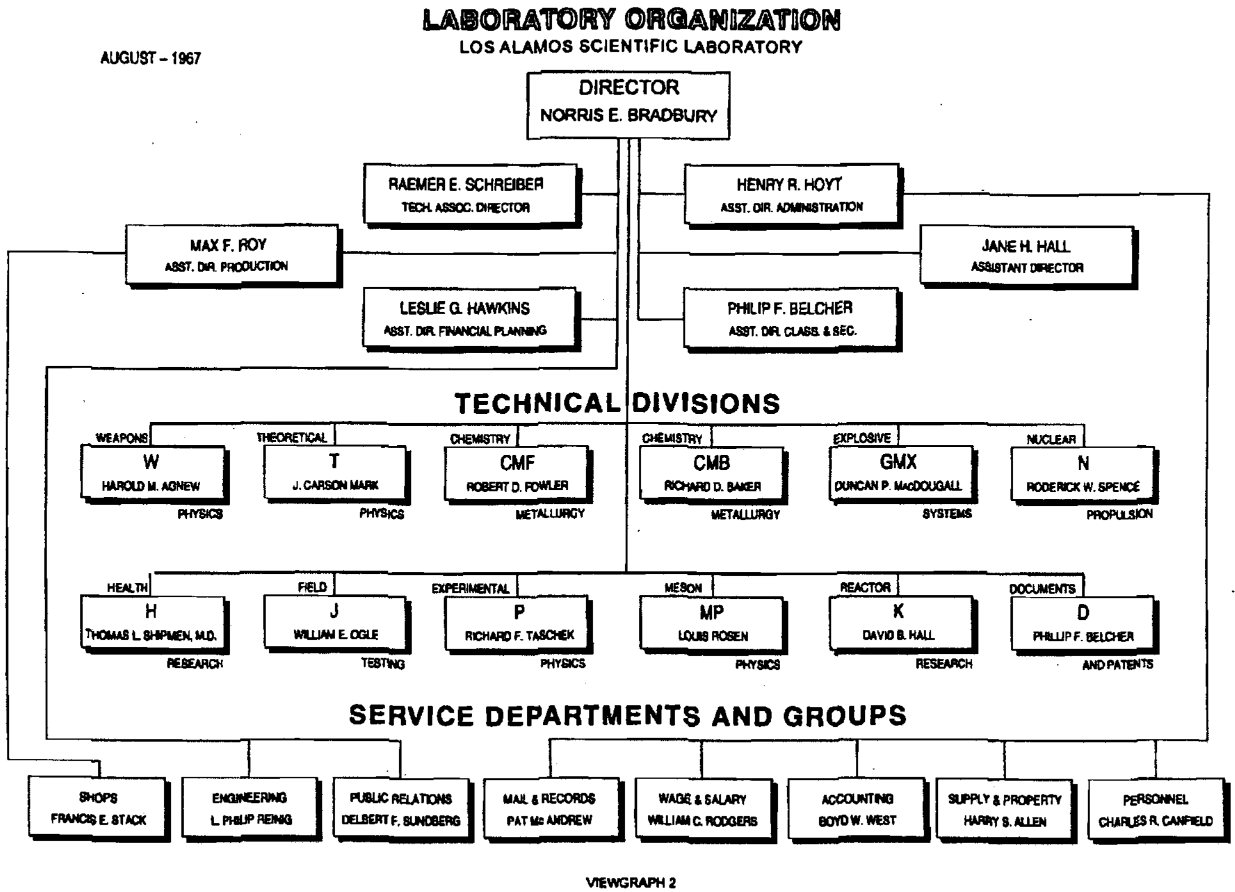

Figure I-1. Laboratory Organization August 1967
Source: "Summary, SAC Briefing, August 15, 1969," W-9-481 (U) (August 25, 1969), p. 8, A99-019, 215-17.

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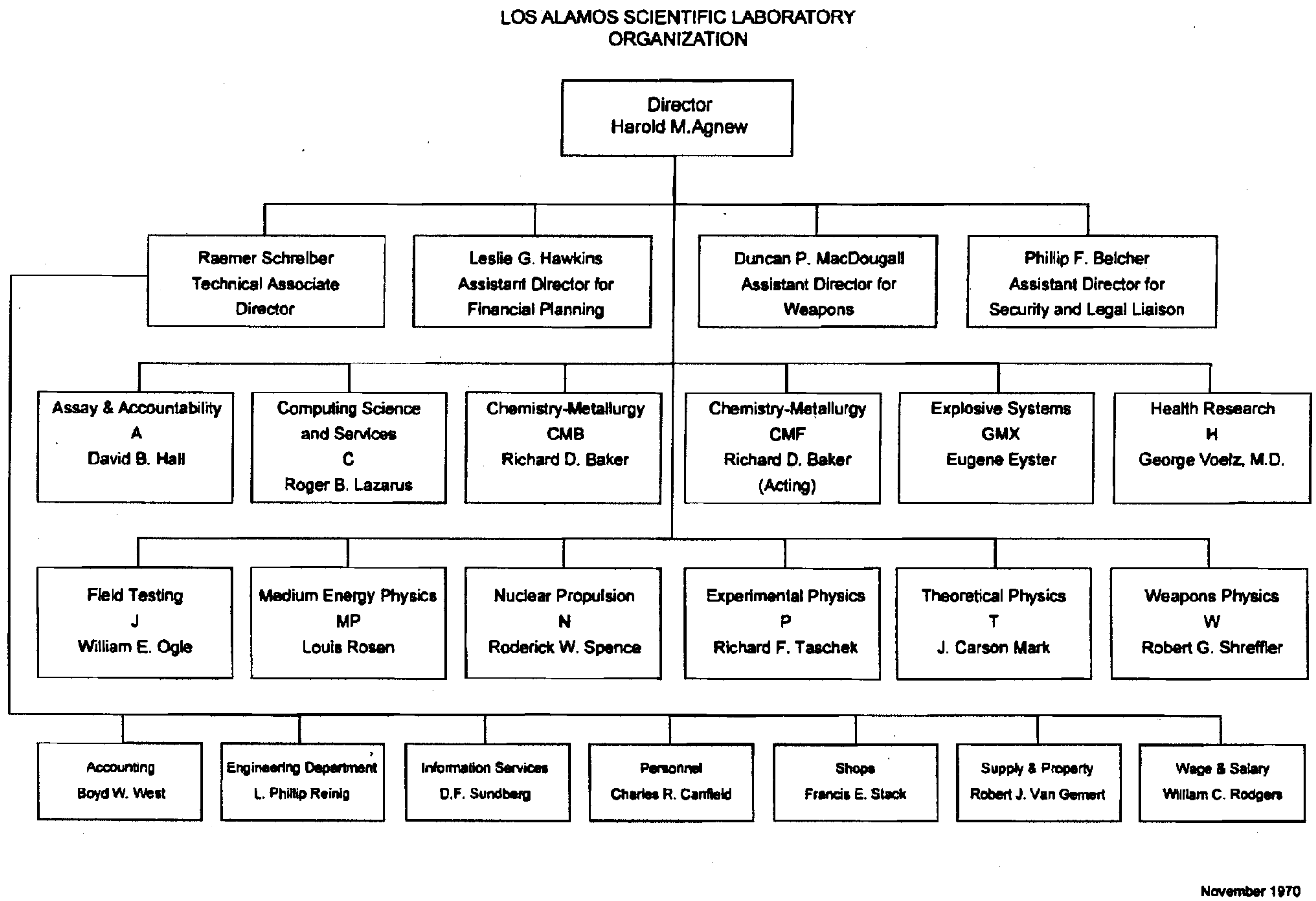

Figure I-2. Laboratory Organization November 1970
Source: "Los Alamos Scientific Laboratory Organization," (U) (November 1970), 1 p., A88-011, 2-30.

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made by the Defense Department. It we weren't providing the technology that allows these high yields in smaller packages to be made we wouldn't be keeping up with the Soviets because the number of Minuteman we have is the same and the number of submarines is the same. It is the warhead technology that enables this country to keep up its deterrent, and that is only because of the technological base which the weapons laboratories supported by the Committee and the Commission provide the country."[4]

As part of his new job as director at Los Alamos, Agnew would continue and intensify his campaign for Los Alamos to receive the Phase 3 assignment for the W76. He was successful in this effort.

C. Weapon Group Designations/Responsibilities, Support and Basic Research Groups, and Committee Functions

As noted in the organization charts of Figures I-1 and I-2, the work at Los Alamos took place along the lines of various disciplines. A set of Divisions, each concerned with a particular interest was set up. In each Division there were groups where the work was again more narrowly specified. However, to produce a specific weapon, members from all the different divisions came together as needed. The following sections will attempt to explain how the Laboratory functioned in terms of organization.

1. Weapon Groups: 1966–September 1972

a. Weapon Design

Very early in the history of the various groups in the Laboratory (1948–December 1970), W-4 was designated as the small weapons theoretical design group responsible for the design of single-stage devices and primaries. However, in January 1971, a division known as TD-Division, responsible for the theoretical design of nuclear weapons, was created. Group members in W-4 then became group members in what was designated TD-4.

Until the formation of TD- and C-Divisions, members of T-Division were responsible for computing, code development, theoretical problems in mathematics, and some aspects of weapon design. For a number of years, until 1973, Carson Mark was the Division Leader. Another important member of the division office at that time was secondary designer Robert Thorn. Until Thorn became TD division leader in 1971, he also headed T-2. (A "new" T-2 group called the Nuclear Data group was then formed in April 1971.) Formed in September 1959, T-3 was the hydrodynamics group. Until it became TD-1 in January 1971, T-4 (which had become a group in May 1970) was also a weapons group in T-Division. (Beginning in October 1971, the "new" T-4 became the group concerned with equation of state and opacity.) The group T-5 members were concerned with numerical analysis; in January 1971, this group became TD-5. From July 1963 until January 1971, T-6 was the fission weapons design group. [Author's note: This group under Dave Woods was apparently a backup design group for the other design groups. By having multigroups, it was possible to see if the design teams agreed.] Group T-7 was the computer research and development group. In April 1968, its members joined C-Division. Members of T-8 were concerned with applied mathematics (mathematical methods). Their well-known group

[4]"Remarks by H. M. Agnew Concerning Need for Testing," (June 15, 1970 Briefing), DIR-2244 (SRD) (October 9, 1970), pp. 7.6–7.7, A99-019, 269-1.

leader was Stanislaw Ulam. In the January 1971 reorganization, members of this group were split into TD-5 and TD-6. The weapon effects group was T-12—until the group was dissolved in July 1968. Once TD-Division and C-Division were formed, the interests of members of T-Division were those required to provide theoretical and analytical support to most of the major programs of the Laboratory.

C-Division was formed in April 1968 from parts of T-Division and Data Processing. This division was called the Computing Sciences and Services Division. Thus the name indicated the type of work for which the division member's were responsible. Nicholas Metropolis served as an advisor from April 1968 to March 1974. In 1972, the members of C-Division were responsible for maintaining and operating one IBM 7094, two CDC 7600s, three CDC 6600s, two IBM 1401s, and one IBM 1360. In addition, the members' interests included research in statistical theory and development of methodology, consultation, assistance in numerical procedures and techniques for problem solving, numerical analysis, and applied mathematics and programming.

On January 1, 1971, a new division was formed that included the "old" T-2, T-4, T-5, T-8, and W-4 groups. This division was called TD, or the Division of Theoretical Design. Members of the division office included several members of the Los Alamos weapon design team. Robert Thorn was the division leader with Harry Hoyt the alternate division leader. TD-1 was called the Thermonuclear Weapons Physics group. TD-2 was the Thermonuclear Weapons Design group. It was this group that was chiefly concerned with the design of secondaries. TD-3 was Weapons Outputs. Another very important group was TD-4, Small Weapons Design. This group was responsible for the design of single-stage weapons and the primary in multistage weapons. TD-5 was called Codes Development. TD-6 was the Monte Carlo group. Concerning TD activities as of June 1972, it has been reported, "This Division is responsible for the theoretical design of nuclear weapons. The Division is responsible for work on the physical principles of nuclear weaponry, research and development on new concepts, and output effectiveness studies of various classes of weapons. An important portion of the effort is directed toward design and interpretation of nuclear weapon tests. ...The personnel of the Division perform calculations based on fundamental theory but use as a database experimental data from other groups of the Laboratory."

Most of the work in T, C, and TD took place in the main technical area, called TA-3.

b. HE Production and Development and In-House Field Tests

A division called GMX was formed in 1948. This division, divided into a large number of groups, was responsible for explosives and "their interaction with metal." Duncan MacDougall was division leader from August 1948 until September 1970 when MacDougall became Assistant Director for Weapons. [Author's note: It should also be noted that another strong figure in the early weapon program was Max F. Roy. He served in the director's office as Assistant Director for Production from August 1948 until his retirement in June 1970. There is a story that circulates in the laboratory that Max Roy wanted to contract work out, but MacDougall wanted the work done in-house.] Eugene H. Eyster served as alternate GMX division leader between 1954 and 1970 when at that time he became division leader.

GMX-1 was the nondestructive testing group. As will be noted, this group became, in September 1972, M-1. Their main work site was TA-8 (Technical Area 8). This site is known as

GT site in honor of Gerold Tenney. X-ray techniques were important in the diagnostics conducted by this group. The group also had test facilities at TA-40, also known as DF Site.

Group GMX-2 was the explosives research and development group. It would become WX-2. Included in the GMX-2 work was the development of new types of explosives. Nemo development was also successfully accomplished. The group members worked at the site known as TA-9 or Anchor Ranch. The group also had test facilities at TA-14, also called Q Site.

GMX-3 was the large high-explosives and implosion-systems group that would become WX-3. This was an important group that was responsible for much of the work relevant to high explosives. The large site known as S-Site, TA-16, was the site at which work on explosive manufacture, machining, and testing took place. There was also an HE burning ground. (TA-16 included several sites that had previously, during the Project Y period, had specific names.) The group also had test facilities (including a drop tower) at TA-11, or K-Site.

GMX-4 was the pin techniques group and as such its members were responsible for the pin shots conducted at TA-15 (also known as R Site). Eric L. Peterson was group leader from 1948 until 1971. This group would become M-4.

GMX-11 was the Phermex group. As the group name implies, the members of this group used the Phermex facility to provide important diagnostics on weapon behavior. They too used the TA-15 site. Douglas Venable was group leader from November 1963 until September 1972. Under reorganization in September 1972, the group become M-2.

GMX-6 was the group concerned with optical techniques. It would be this group that would in general, as part of the weapons program, do case diagnostic and related shots. Their test facilities were at TA-39, known as Ancho Canyon Site.

GMX-7 was the group responsible for detonators, firing, and cables. This group would become WX-7. The main area for operation of this group was TA-22, known as TD (Trap Door) Site. Test facilities were also located at TA-40, DF Site.

GMX-8 was the explosives phenomena group. In the 1972 reorganization, this group became M-3. Their test area was at TA-36, known as Kappa Site. The specific areas at this site had names such as Eenie, Meenie, Minie, and Lower Slobbovia.

GMX-9 was the photography group, known as the fast cameras in optics. Their group leader was Berlyn Brixner. Their laboratories were at TA-8.

GMX-10 was called the statistical mechanism and detonation theory group. This group was dissolved as part of the 1971 reorganization.

The GMX field-test groups, and later the equivalent M field-test groups, gave their field-test shots numbers. Thus, as will be noted in the following chapters, each shot record is identified by a specific shot number.

c. NTS Test

The division responsible for the preparation and completion of tests at NTS, including certain diagnostics, was J-Division. This work included ensuring that all the tests were conducted safely and, for the underground tests, the use of proper stemming techniques to ensure containment. The division members also were responsible for the construction and maintenance of field-test facilities. Thus, the work included mechanical design engineering, structural analysis, vacuum technology, and underground phenomenology. Several members were concerned with nuclear weapon effects. William Ogle was division leader from 1965 until October 1972 at which time Charles I. Browne became division leader.

J-1 was concerned with personnel and administration. Group J-3 was responsible for plans, operations, and administration, NTS. Beginning in 1965 the group was located in Nevada under the leadership of Robert Beiler (who left the group in 1979). J-6 had the responsibility of engineering and construction, or facility production. Equipment, engineering and specifications, including downhole design were the responsibility of J-7. J-8 was the electrical engineering group, and their responsibilities included overseeing the timing and firing of the test device.

From March 1971 until September 1979, the group J-9 was known as the underground test phenomenology group. The diagnostics based on radiochemistry were performed by members of J-11 from 1951 until January 1971 when the nomenclature of this group became CNC-11 (Nuclear Chemistry). The laboratories and analytical equipment required for the J-11 radiochemistry program were located at TA-48. (Calibration of equipment and similar activities were conducted at the reactor at TA-2.) Group J-12 was responsible for neutron measurements. In July 1971, the name of the group was changed to Neutron Measurements—PINEX. During the same time period, members of Group J-14 were responsible for the reaction history diagnostics. (During 1966, J-14 had been formed from personnel from J-10.) As part of their responsibilities, J-15 members were responsible for hydrodynamic yield. In general, members of the J-Division groups were greatly assisted by organizations such as EG&G and REECO that were contractors to the Laboratory.

In 1972, the division was known as J-Division Field Testing. The various weapon-related groups in this division as reported in November 1972 are noted below:

Group	Name
J-1	Operations
J-3	Operations NTS
J-6	Facility Production
J-7	Downhole Design
J-8	Timing and Firing—Phenomenology Support
J-9	Underground Test Phenomenology
J-12	Neutron Measurements—Pinex
J-14	Reaction History
J-15	Diagnostic Design Hydrodynamics

d. Engineering and Design

W-Division was the designation of the nuclear weapons engineering division. The division members accomplished Phase 3 development for all non-HE components, built prototytpes for NTS shots and performed tests to see how a weapon might behave. In addition, W-Division was the principal point of contact within the laboratory for all nuclear weapons programs. As previously noted, Harold Agnew was the division leader from August 1964 until he became director in the fall of 1970. He was then replaced with Robert G. Shreffler. The division was dissolved in September 1972 when most groups joined WX-Division.

The W-1 group was known as weapons engineering. In September 1972, it became WX-1. For many years, Jacob J. Wechsler headed this group. The group was located in the canyon at

TA-41. Group W-7 was the group concerned with the physical and chemical properties of weapon materials. They too were located in Los Alamos canyon at TA-41. This site had a tunnel in the hillside used for secure storage. The tunnel was known as the Ice House, a carryover from Project-Y days when the storage facility was a former ice house. The group had a varied assignment program that covered such diverse activities as responding to accidents involving nuclear weapons to the study of pit hydriding. This group became WX-5.

W-3 was the group concerned with gun-device engineering. The work of this group will be noted in Chapter V in the discussion of the LASL gun-type weapon programs. This group was located at TA-33.

Group W-8, before it was dissolved in February 1972 and absorbed by P-3, was the group responsible for vulnerability and neutron physics. Group W-10, which became a group in 1970, was designated X-Ray Effects on Weapons. It became WX-6.

As will be noted in Chapter V, W-9 was formed in 1968 to provide an interface between the Laboratory and the Military. This group was called the Department of Defense Liaison group. In effect, the group members had the responsibility of "explaining" laboratory programs to the Military and responding to the large number of requests, such as input for the Phase 2 reports, from the DOD and related departments.

e. Materials

In 1972, CMB-Division personnel were responsible for both basic and applied research and development in the fields of chemistry, metallurgy, and chemical engineering.

f. Radiochemistry

In 1971, the former J-11 group was moved into the CNC-Division. The members of CNC, as well as providing the radchem test yields, were interested in low-temperature physics, the study of transuranium elements, and radioactive half-lives.

2. Weapon Groups: Reorganization and September 1, 1972, Designations

The following changes were made when the two new divisions WX and M were formed on September 1, 1972:[5]

WX-Division		M-Division	
New Designation	Old Designation	New Designation	Old Designation
WX-1	W-1	M-1	GMX-1
WX-2	GMX-2	M-2	GMX-11
WX-3	GMX-3	M-3	GMX-8
WX-4	W-3	M-4	GMX-4
WX-5	W-7	M-5	GMX-9
WX-6	W-10	M-6	GMX-6
WX-7	GMX-7		

[5] "Minutes of the 177th X-Unit Steering Committee Meeting (U), September 21, 1972," WX-7-72-4 (SRD) (October 13, 1972), pp. 2–3, B11, Drawer 53, Folder 1 of 2.

E. H. Eyster was appointed WX-Division Leader with B. L. Moore, M. L. Brooks, and R. W. Drake in the Division Office. For M-Division, W. E. Deal was appointed Division Leader, with Douglas Venable, W. W. Wood, J. J. Erpenbeck, and F. R. Parker in the Division Office.[6]

M-Division was known as the Dynamic Testing Division. Thus, the members of this large division were responsible for all the on-site field tests so necessary in the weapon program. The new M-1 group was known as Nondestructive Testing, and its members continued to be at TA-8. M-2 was the Phermex group. Members of this group were, of course, located at TA-15. M-3 was Detonation Physics (located at Kappa Site). M-4 was Pin Diagnostics and Neutron (located at R Site). M-5 was Optical Engineering and Repair. M-6 was Shock Wave Physics (located at Ancho Canyon).

After it was formed, WX-Division was originally designated the Weapons Engineering Division. The division office included a staff responsible for the overall management of such areas as engineering, plans and budgets, operations, hydrodynamics, testing, weapons systems, advanced development, new technologies, and reimbursable programs. WX-1 was given the name Nuclear Components and Engineering. Again, Wechsler headed this important group at TA-41. WX-2 (TA-9) under Louis C. Smith was called Explosive and Other Materials Development. Staff members would, as pointed out in Chapter IV, play a critical role in the development of new materials for the XW76. With the group headed by Jesse Aragon, Group WX-3 members were concerned with high-explosive implosion systems development. The group continued to operate the facilities at TA-16 and TA-11. The gun group, WX-4 (TA-33) was absorbed into WX-5 in April 1973. A new WX-4 group formed in December 1975 was responsible for design systems. It had formerly been ENG-6.

The material development group formerly W-7 was renamed WX-5. The group continued to work at TA-41. W-10 became WX-6, and the group members continued to be concerned with vulnerability and lethality. Although GMX-7 was renamed WX-7, the group members continued to be concerned with detonators and detonating systems at TA-22. Their work on the XW76 will also be noted in Chapter IV.[7]

3. Support and Basic Research

Not included in this list are the various required support groups. These included groups whose members were involved in personnel, payroll, procurement, engineering, component fabrication, health and safety, the technical library, and similarly important functions.

Moreover, there has always been the philosophy at Los Alamos that to have a viable weapons program the laboratory also had to be a first-rate scientific research facility. Thus, there were several groups whose members were interested in basic research in mathematics, physics, biology, materials, and similar scientific disciplines. There was also a great deal of interest in the development of new diagnostic tools, including accelerators.

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[6] "Minutes of the 177th X-Unit Steering Committee Meeting (U), September 21, 1972," WX-7-72-4 (SRD) (October 13, 1972), pp. 2–3, B11, Drawer 53, Folder 1 of 2.

[7] Alison Kerr et al., two-volume informal history of the organizational structure of the Los Alamos Laboratory, (U) (no date), located in the Los Alamos archives. Applicable Los Alamos phone books (U). "Nuclear Technology and Analysis Report (U)," Field Command Defense Nuclear Agency, Kirtland Air Force Base, New Mexico 87115 report FC/06720008 (SRD) (June 1, 1972), pp. 56–61, B11, Drawer 57, Folder 1 of 1.

Beginning with the Niblick operation, testing went on more or less continuously. However, the same program of deciding on a test list and the use of an operation name was continued. The named operation extended from one fiscal year (FY) to the next. Thus, the Storax operation extended through June 1963. Niblick operation tests continued from July 1963 through June 1964. Whetstone tests continued from July 1964 through June 1965. Whetstone was followed by Flintlock that took place from July 1965 until June 1966. Flintlock was followed by Latchkey, FY1966–FY1967; followed by Crosstie, FY1967–FY1968; followed by Bowline, FY1968–FY1969; followed by Mandrell, FY1969–FY1970; followed by Emery, FY1970–FY1971; followed by Grommet, FY1971–FY1972; and this operation was in turn followed by Toggle, FY1972–FY1973. The reader will notice these names throughout the remaining chapters.

The name of each operation was chosen in Washington.[8] DMA [Division of Military Application] staff member Ken Adney recalls that while he was at DMA in the 1960s–1970s, he and staff member Irv Williams would propose names for the operation. They tried to think of names that might be related to the particular service of the Military that the person in charge belonged to. Once the list was presented to the person in charge, [such as the Director of Military Application or later the Assistant General Manager for Military Application] this person then selected the operation name from the list.[9] The Whetstone through Toggle series appear from their names to represent small, but important, items that were used, or had been used by those in the service. The name Niblick was perhaps a reminder that someone liked to play golf.

2. Event

With as many tests as the U.S. conducted, it was a nontrivial task to specify a suitable event name for every test.

After the early test program, a formal procedure for naming names was initiated. In order to make the task more organized, the decision was made to designate a family class of nouns. The family type (along with names representing this family) was submitted to the Atomic Energy Commission (AEC). The AEC in turn would announce which names had been approved. These families of names included San Francisco streets, types of cheeses, games, nautical terms, plants, animals, Indian tribes, and tools.[10]

Perhaps one of the best sources of names for the Los Alamos group was to make use of the place names in New Mexico. In 1965, the University of New Mexico press published a small book called *New Mexico Place Names, a Geographical Dictionary*, edited by T. M. Pearce, assisted by Ina Sizer Cassidy and Helen S. Pearce. Most place names found in New Mexico are listed in this publication, and a short paragraph explains where the named location is and how the name originated. This dictionary contains more than 5,000 individual items. With such a dictionary in hand, the Los Alamos weapon groups found it easy to obtain shot names.

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[8]John C. Hopkins, personal communication (U) (January 15, 2003).

[9]Patricia Nolin Bodin through John C. Hopkins, personal communication (U) (February 11, 2003).

[10]John C. Hopkins, personal communication (U) (June 7, 2002).

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CHAPTER II
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LIST OF FIGURES

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The basic idea came from Famularo, Juveland, and Cremer; Bernard and Jacoby contributed to the development of the principle in HE-driven systems. It started with a study of gun devices in an attempt to make them lighter and to drive them with lower reactivities." Additional historical information is available in the cited reference.[14]

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[14]Beverly A. Wellnitz, "Weapons Working Group, Minutes of the 215th Meeting," WWG-215 (SRD) (October 29, 1969), pp. 5–6. A99-019. 92-19.

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6. Lessons Learned

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However, there were even problems in getting some of the necessary input data. For example, the meeting minutes of the January 7, 1971, Hydrodynamics Working Group report that Deal [representing GMX at the meeting] had said, "...we apparently do not know how to

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The history of the early Livermore design program is the subject of LA-13755-H (SRD), and for more information the reader is referred to this document.

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The Bradbury memo was followed by the establishment of the Small Systems Group. During their first meeting on August 29, 1957, the group members decided that a delegation from Los Alamos should visit Livermore in September.

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Staff members visited Livermore to discuss Livermore systems. Various reports from Livermore were sent to Los Alamos. (As an example, the director files at Los Alamos contain reports that describe the Livermore program in the late 1958–1965 time period.) The two design groups met at various meetings such as the JOWOG meetings where information on the Laboratory design programs was exchanged. There was the design verification program that took place between the laboratories during the moratorium (see LA-12950-H (SRD)).

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a. Military Requirements for Small, Lightweight Warheads

As noted previously, in the mid-1960s the Los Alamos design group had begun work on 10-inch diameter or less primaries.

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The reason for this great interest on the part of the design laboratories in the 10-inch and less diameter was the fact that the Military was pushing for small, lightweight systems. By this period, the missile/guidance/nose-cone establishment in the United States had developed their systems to where it appeared that it would be possible to put several warheads on one intercontinental ballistic missile (ICBM), deploy the missile, and have each of the warheads hit a different target. This concept is referred to as use of multiple independent reentry vehicles (MIRV). It was felt at that time that the USSR was also going into these types of systems. Because a warhead is much less costly than a missile, the Military wanted to pack as many warheads as possible into each missile. This desire for as many warheads as possible on one missile pushed the nuclear weapon groups to achieve as small as possible in terms of diameter. Moreover, the Military wanted as long a range as possible for each missile; this requirement pushed the weapon groups to try and design minimum-weight warheads.

A request for multiple-carriage capability for the forthcoming improved Minuteman system was formalized in a January 1963 revision to the Phase 1 study. Three reentry vehicles were to be carried in this system—designated the Mk 12 (L). On February 12, 1964, Phase 3 authorization was given for the Mk 12 (L). Livermore and Sandia Corporation, Livermore, were to receive the assignment (the warhead would carry the designation XW62). In November 1964, the Military Characteristics were amended to provide a warhead "compatible with a MIRV application on the advanced Minuteman missile system."[95]

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On August 31, 1964, in a letter to AEC Chairman, Glenn Seaborg, Harold Brown, Director of Defense Research and Engineering, formally proposed the lightweight warhead program. Later, a paper titled "MIRV on Minuteman

[95]Betty L. Perkins, "Tracing the Origins of the Modern Primary: 1952-1970 (U)," Los Alamos National Laboratory report LA-13755-H (SRD) (April 2, 2001), pp. XII-7–XII-14.

and Titan II" and dated March 3, 1965, was provided to the administrations at the weapon-design laboratories.

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c. Los Alamos—Livermore Discussions, March 1965

A Joint Working Group (JOWOG) 21 meeting was held at Livermore on March 16–18, 1965.

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~~In addition to their attendance at the meeting, the Los Alamos~~ attendees, George White, S. R. Orr, Eldon Pequette, and Robert Osborne, apparently visited privately with Sack. Their classified notes on this meeting were forwarded to Los Alamos [100]

(b)(3)

[100] C. T. Brockett to Helen Redman, (U) (March 23, 1965), p. 1, A99-019, 273-4.

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By June 1966, the Livermore teams were almost certain that they were going to receive the Phase 3 assignment for the Poseidon Mk 3.

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1. Loss of the Poseidon C-3 Warhead to Livermore

In March 1965, a paper titled "USN Missile Force Improvement Summary" was published under the sponsorship of the Institute for Defense Analyses. This paper suggested a design for a small reentry vehicle designated the Mk 100 and reported that eight of the Mark 100s could be included in the Navy's Polaris A-3 system.[107]

By April 1965, the Navy decision makers had decided on a new missile to be known as Poseidon. Compared to the Polaris A-3, the Poseidon was to be longer and have a larger diameter, carry a heavier payload, and achieve a greater range. Each missile would carry multiwarheads and would use a space bus to carry and distribute the warheads on target.[108]

A December 6, 1965, letter from the Chief of Naval Operations requested AEC participation in the Poseidon conceptual studies. On the cover sheet of this letter, there is a note written by a person in the Los Alamos management to the effect that Los Alamos had requested that the Navy invite Los Alamos to compete on the Poseidon assignment. The note stated, "…we [LASL] should really go after the business."[109]

On January 13, 1966, Director of Defense Research and Engineering, John S. Foster, Jr., in a letter to AEC Chairman Glenn T. Seaborg indicated that the Navy was favoring the Mk 100-type, small-reentry vehicle with its multiwarheads for use on the new Poseidon C-3 fleet ballistic missile.[110]

Representing the various groups at Los Alamos, on April 28–29, 1966, Peaslee, Aragon, Horpedahl, and Hoverson attended a meeting in Washington on the Poseidon C-3 missile system.

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[107]"USN Missile Force Improvement Summary (U)," Institute for Defense Analyses Pen-X Paper 59, IDA/HQ 65-3610 (SRD) (March 1965), pp. 9–10.

[108]"Weapon Development Status Report (U)," Headquarters Field Command Defense Atomic Support Agency, Sandia Base, Albuquerque, New Mexico report FC/04650121 (SRD) (April 1, 1965), p. 14, A99-019, 160-1.

[109]Harry B. Hahn to Director, Division of Military Application, U.S. Atomic Energy Commission (SRD) (December 6, 1965), 2 pp., A99-019, 217-15.

[110]John S. Foster, Jr. to Honorable Glenn T. Seaborg (SRD) (January 13, 1966), 2 pp., A99-019, 217-15.

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In May 1966, the AEC published a Phase 2 feasibility study for a warhead for the Poseidon C-3 missile system. Proposals from the Los Alamos Laboratory were included in this study.

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Although the Los Alamos group very much wanted the assignment of the Navy's warhead (to be known as the W68), such was not to be the case.

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Bradbury wrote a letter dated June 1, 1966, to Livermore director Michael M. May.

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Bradbury proposed a "pie split"—Livermore would take the Mk 3 Poseidon warhead and Los Alamos would take the warhead for the Mk 18.[113]

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This decision must have been reinforced after hearing from the Peaslee delegation, when they returned from Washington, as to how badly Los Alamos had come off in the bid for the W68.

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On April 4–5, 1966, a group from Los Alamos composed of William Deal, E. L. Peterson, D. M. Mosher, and Gene Eyster from GMX Division and Bill Davis from W-1 visited Livermore.

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[113]N. E. Bradbury to Dr. Michael M. May (SRD) (June 1, 1966), 2 pp., A99-019, 186-2.

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The meeting minutes then state, "T Division and W-4 will make calculations, and GMX will make the usual types of local tests. W-1 will order mock pits and cases from Oak Ridge, and the HE parts (9404) can be made at Pantex. Fifteen sets are being ordered to start with, for pin, optical and Phermex shots."[116]

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Detailed information on these shots is available in the cited references.

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[116] Beverly A. Mohr, "Weapons Working Group Minutes of the 160th Meeting," WWG-160 (SRD) (May 11, 1966), p. 10, A99-019, 92-11.

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It would appear that sometime in late April or May of 1967, groups from Los Alamos again visited Livermore. In a letter dated June 2, 1967, Bradbury thanked Livermore Director, Michael May, for the help that the Livermore staff had given to staff from GMX and to Jim Frank and George Fogelson from T-Division.[127] Included in the help given to Fogelson were the transmittal of five Livermore codes, including the tapes and instructions on how to use them.[128]

The WLPC members met on June 13, 1967. Included in their discussions was the Mk 18.

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This effort would include layout drawing, including weight and center-of-gravity calculations and RV synthesis, as well as studies on vulnerability.[131]

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[127]N. E. Bradbury to Dr. Michael M. May (U) (June 2, 1967), 1 p., A99-019, 273-4.

[128]Jack W. Rosengren to Dr. Jane Hall (U) (June 8, 1967), 2 pp., A99-019, 273-4.

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[131]Beverly A. Wellnitz, "Weapons Working Group Minutes of the 179th Meeting," WWG-179 (SRD) (July 5, 1967), pp. 6, 8–9, A99-019, 92-14.

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1. Initial Considerations

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The Hydrodynamic Committee was assigned the job of naming the proposed primary.[144]

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2. Class Name

Towards the end of November 1967, the problem of what primary to use in the Mk 18 was somewhat resolved.

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[144]Jane H. Hall to Distribution, Subject: "Memorandum of Understanding – WLPC No. 21," AD-1814 (SRD) (November 13, 1967), p. 1, A99-019, 91-10.

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'This means that every detail will have to be worked out in order to design local tests, attachments, etc. He has requested help from Sandia Corporation in this work."

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For example, at the WWG meeting of February 21, 1968, it was reported that LASL had been assigned development responsibilities for the Mk 18. Bradbury commented that LASL had better pursue all versions of the Mk 18. During the meeting various possibilities for the warhead's design were discussed by Peaslee.

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a. Design Program

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'During the WWG meeting of March 13, 1968, Osborne explained his work up to that point.

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On March 15, 1968, Osborne wrote Sack at Livermore

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Osborne indicated that he would like to visit Sack and bring Martin Torrey and Al McKnight with him to discuss details of two-dimensional hydrodynamic calculations

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satisfactory, no above-background levels of radioactivity had been detected.

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~~A catcher~~ container for prompt radiochemical sampling would be mounted in the rack above the canister and retrieved after the device had been detonated. Dry nitrogen purging would be used to maintain a benign environment. Browne noted that temperature and humidity conditions would be monitored from the time of emplacement until shortly before zero time.[215]

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For additional information, the reader is referred to the cited reference.[223] The relevant GMX progress reports give more detailed information.

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[223]"Program Status Weapons Research and Development, October – December 1969 (U)," DIR-2195 (SRD) (no date), p. 19.

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Diagnostics were to be alpha, time interval, radiochemistry, and on the secondary (1) Pinex

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(originally an acronym for Pinhole Neutron Experiment)—using the television time integrated method; (2) TRAX (Time Resolved Asymmetry Experiment)—time and space resolved measurement of 14-MeV neutron production in the boost region; and (3) RTA (Radiation Time of Arrival)—radiation time of arrival where observation was made of x-rays through a transparent hole in the case. It was noted that the rack design was very complicated and that the design and fabrication schedule was tight.

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a. Purpose

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e. Case Studies

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b. Initial Considerations

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Associate Director for Weapons, Duncan MacDougall, was an unhappy man.

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1. **Considerations behind the Model 2**

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2. Field Tests of the Model 2

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1. **Proposal**

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CHAPTER III
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1. Livermore: A Small, Lightweight Secondary

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In the mid-1950s the U.S. Military began to push for smaller, lighter nuclear weapon designs. At Livermore, the secondary design team began work on the design of a secondary suitable for this application.

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b. Influence

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2. Los Alamos: 1959–1964

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After Hardtack, a moratorium on testing went into effect.

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This type of lightweight device was the design objective of a UK/U.S. study group called JOWOG-3 (Joint Working Group 3).

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/R. Thorn discussed this design concept at the July 16, 1959, meeting of the TWG.[5]

The design was again discussed by R. Pollock during the August 20, 1959, TWG meeting. By now the design was more complete.

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[5]"Minutes of the Third Meeting of TWG." TWG-3 (SRD) (July 30, 1959), p. 4, A99-019, 87-8

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B. Los Alamos 1965–1968 Design Program Involving a Small Secondary

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2. Early Mk 18 Program

a. Options for a Warhead for the Minuteman III Missile

In the mid-1960s the Military began to consider a possible Minuteman III missile that would employ a multiple warhead carriage. The warhead for this application was designated Mk 18.

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In a June 1, 1966, memo, Bradbury proposed to do a "pie split" with Livermore. If Livermore would support Los Alamos receiving the Mk 18 assignment, Los Alamos would not oppose the assignment of the Mk 3, the Poseidon warhead, to Livermore.[35]

In a TWX dated June 23, 1966, AEC Director of Military Application, Delmar Crowson, informed the Laboratories that in order to have different nuclear design approaches for the Mk 3 and Mk 18, he was going to assign the Mk 3 to Livermore and the Mk 18 to Los Alamos.[36]

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[35]N. E. Bradbury to Dr. Michael M. May, DIR-2032 (SRD) (June 1, 1966), 2 pp., A99-019, 186-2.

[36]USAEC Delmar L. Crowson, Wash., D.C. to RUWPQA/USAEC L. P. Gise, Albuq., N. Mex., et. al. (SRD) (June 23, 1966), 3 pp., A99-019, 182-1.

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However, there was never a request for weaponization of such a device and the program was dropped.

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C. BMP Program and the Mk 18

1. Concerns With the Primary in Terms of Secondary Design

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[Author's note: This proposal of Peaslee's would become the BMP program. The BMP program and the test program that grew out of this are included in the following sections. Each section describes a relevant test.

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d. Secondary Design

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e. Execution

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f. Secondary Performance

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g. **Bradbury's Directive**

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He again expressed this directive in a May 29, 1969, memo to Mark and Agnew.[79]

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a. **Redesign**

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[79]N. E. Bradbury to J. Carson Mark and H. M. Agnew, DIR-2177 (SRD) (May 29, 1969), 1 p., A99-019, 91-10.

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The necessary information for the required performance of the display scopes, interlocks, and timing scopes as well as the dry-run system was provided by Carlton Young in a December 8 letter to the EG&G group in Nevada.[95]

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The fluor was imaged on the television system with a

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[95]Carlton S. Young to Robert Kost/Al Tarr, EG&G, Inc., P.O. Box 295, Mercury, Nevada 89203 (CRD) (December 8, 1969), 5 pp., A99-019, 258-12.

Newtonian telescope; a beam splitter formed images for two television cameras. Proximity focus image intensifiers excluded gamma-produced light before neutron arrival and debris-produced light thereafter. The instrument package was protected by kinking the path from the device as much as possible and placing baffles along the optical path pipe to prevent neutrons and gamma rays from reaching the television package."[97] The TV Pinex technique had first been used by the Los Alamos group on the Rickey test fired in 1968. TRAX was a time-resolved asymmetry type experiment. In this type of diagnostic an array of detectors viewed the boost region through collimators to give both a time and energy resolved measurement of the 14-MeV neutron production in the boost region. This technique was first used on Door Mist in 196[illegible].[98]

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[98] R. W. Peterson to Doug Venable, WPC-O, Subject: "List of J-Division Diagnostics," J-DOT – JRPO-77-4 (SRD) (August 15, 1977), pp. 1–2, A86-049, 1-6.

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c. **Test and Results**

The insertion and emplacement activities took place as outlined by Browne, and no problems were encountered

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Vander Maat discussed his calculations vs the then available diagnostic data during the January 28, 1970, meeting of the TWG. If he used one type of input in his secondary calculations, he obtained a number similar to the fission but not the fuel yield; if he used a different input, he obtained a number similar to the fuel but not the fission yield. Thus, no matter what his input parameters were, he could not get an output consistent with the observed data. The meeting minutes state his conclusions, "The fuel results indicate that either we do not know how to calculate fusion and fission or we do not know how to interpret the radiochemical results."[104] This problem, as will be noted in the following paragraphs, would continue to bother ~~the design team.~~

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[104] "Theoretical Weapons Group, Minutes of the 135th Meeting," TWG-141 (SRD) (January 28, 1970), p. 4, 18, A99-019, 87-15.

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a. **Specifications**

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b. Implementation and Instrumentation

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c. **Test and Results**

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a. Proposal

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b. Implementation

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c. **Results**

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d. Informing the Military

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e. Looking Ahead to a Navy Decision

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a. Proposal

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H. W. Kruse, a staff member in J-14, outlined the reaction history detector requirements in a January 19, 1970, memo. Included were specifications not only for the number and types of detectors, but also for their distances from the device, the layout of the collimators, cable requirements, and the types of compensators to be used. This memo was sent to representatives of Edgerton, Germeshausen, and Grier, Inc. (EG&G) and J-7 and formed the basis for the required rack and detector layout designs.[180] These instructions were followed by a January 26 letter from Kruse to Sandoval at EG&G providing information on the necessary data recording scopes, trigger signals, timing requirements, prebase markers, interlock signals, and the dry-run system.[181]

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[181] H. W. Kruse to Lee Sandoval (CRD) (January 26, 1970), 7 pp., A99-019, 296-3.

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c. Design

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a. **Initial Work**

1970

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[redacted] Because none of the attendees objected to any of the listed tests, it was reported that the listed shots were therefore tentatively approved [211]

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1971

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[211] D. P. MacDougall to Distribution, Subject: "Memorandum of Understanding – WLPC No. 61," ADW-7 (SRD) (October 9, 1970), p. 3, A99-019. 91-11.

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1972

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The attendees at the July 19, 1972, WWG meeting were informed of the proposed FY73 test schedule.

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During 1972, changes to the 1971 revised preshot report (TD-2: 71-38) were proposed in TD-2: 72-113.

1973

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b. Preparations and Test

(b)(3) Diagnostics were to be alpha, time-interval, television-time-integrated Pinex, and radiochemistry.

(b)(3) The WX-3 and the J-Division work programs were on schedule. A tower would be used for the rack.[229]

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229. "Toggle," JOHO-73-8 (SRD) (January 17, 1973), pp. 1–2, B11, Drawer 109, Folder 2 of 3.

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Indeed, the J-Division schedule slipped, but not by a full month.

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c. **MacDougall's Response**

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Pinex pictures had been obtained. The event had been completely contained; detectors, located 557 ft below the surface, had shown no above-background radiation or excessive pressures in their readings.[233]

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[233]Univ. of Calif., Los Alamos Sci. Lab., D. P. MacDougall, Los Alamos, N.M. to BY3/Captain Wayne L. Beech,

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d. Results and Implications

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Good data had been obtained from zero time until 4 μs when a short noise pattern had occurred. The data were again good from 4 to 8 μs after

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which time no further data were collected. Additional information and pictures of the Pinex images are available in the cited reference.[237]]

To conclude the data presentation at the April 18 WWG meeting, radiochemist Bryant reported the radchem results,

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[237]Leslie M. Redman, "LASL Weapons Quarterly (U), for the Period Ending March 31, 1973," Los Alamos Scientific Laboratory report LA-5330-PR (SRD) (June 1973), pp. 60–62.

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g. **Further Discussion**

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a. **Proposal**

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b. Deferred

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It was reported that this test ~~had been deferred~~ on the basis that the information was not needed soon.

a. Moving Forward

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b. Los Alamos Announcements

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~~In a letter dated October 31, 1972, to Na~~vy/Lockheed personnel, R. B. Olwin updated these groups as to the latest plans at Los Alamos for tests of weapon designs that might be suitable for use in the Navy's Mark 400 warhead.

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c. Secondary Design Considerations from the Technical Viewpoint

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e. **Preparations**

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f. Implementation

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g. MacDougall Reports

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MacDougall sent the latest revised data for the major diagnostics to Camm on November 20, 1973.

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h. Results

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Preliminary results were again discussed during the August 15, 1973, WWG meeting. These included a presentation by Kruse of the J-14 data. The TRAX experiment had yielded gamma and neutron signals with good time resolution. Kruse presented graphs showing detector currents for gammas and neutrons. Berzins reported on the J-12 Pinex results. He included a computer analysis of the Pinex data.

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h. Results

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Preliminary results were again discussed during the August 15, 1973, WWG meeting. These included a presentation by Kruse of the J-14 data. The TRAX experiment had yielded gamma and neutron signals with good time resolution. Kruse presented graphs showing detector currents for gammas and neutrons. Berzins reported on the J-12 Pinex results. He included a computer analysis of the Pinex data.

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As discussed in Chapter II, the postshot report ~~on the primary~~ was released on March 14, 1974.

i. Considerations

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a. Objective

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[Author's note: The Mk 500 was the Navy's proposed RB that could maneuver to evade destruction.]

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d. Test Implementation

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e. Results

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f. Significance

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F. Looking Ahead

When the Los Alamos weapons groups received, in the late spring of 1973, the Phase 3 award for the XW76, the secondary-design team had a series of previous tests that they could use as a design base. Although their 2-D code development was somewhat lacking, there were 1-D codes that had been developed, and their use compared with experimental data from relevant tests.

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These temperature environmental tests will be started as soon as the metal parts become available, probably in January."[7]

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[7]Group GMX-3 Progress Report, November 16 through December 15, 1963," GMX-3-3505 (SRD) (no date), p. 4, A86-016, 28-14.

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(Additional information on the complex TX61 program is included in Chapter V.)

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e. **Additional Development Programs at Los Alamos**

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f. **Preparation**

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g. **Behavior**

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The following paragraphs will give the reader some history on the early program.

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The GMX-2 members began both a literature search and an experimental program designed to address the Agnew question.

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This sample was being analyzed to determine whether the manufacturer's normal procedures would yield a sufficiently pure material.[91]

The Quarterly Status report from the Laboratory for the period ending September 1971 summarizes the previous work on the high-hydrogen materials. The report indicates that various materials containing a high weight-percent of hydrogen in combination with low-Z atoms had been, in the previous two years, exposed to gamma rays from a ^{60}Co source.

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The amount of H_2- or H-containing gaseous products evolved per Mrad of energy absorbed had been measured.

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In terms of the most stable organic compounds studied, the report indicates that LiH was only exceeded in terms of radiation stability by NH_4Cl. But the report also notes, "Because of interest in the hydrogen-rich materials for other weapon applications, properties of the compacted materials such as tensile strength, dimensional stability, pressing characteristics, and compatibility with other components are being investigated."[92]

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(b)(3) p. 22, A86-016, 21-4.

[91]"GMX-2 Monthly Progress Report, August 11 to September 10, 1971," GMX-2-MR-71-9 (SRD) (no date), p. 28, A86-016, 21-3.

[92]"Quarterly Status Report on Weapons Research and Development (U), for the Period Ending September 30, 1971," Los Alamos Scientific Laboratory report LA-4820-PR (SRD) (no date), p. 39.

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During the January 4, 1967, meeting of the WWG, R. G. Shreffler, Alternate Division Leader of W-Division, reviewed the vulnerability program. He stated that he felt it essential that the Laboratory continue its efforts in vulnerability studies

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[127] "Group WX-3 Progress Report (U), March 16 through April 15, 1973," WX-3-75-3 (SRD) (no date), pp. 9–10, A86-016, 275-3.

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7. Pu Alloys

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d. Continued Efforts: Sample Preparation

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Questions

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[266]Siegfried S. Hecker and Joseph C. Martz, "Plutonium Aging: From Mystery to Enigma," *Ageing Studies and Lifetime Extension of Materials*, edited by L. G. Mallinson (Kluwer Academic Publishers/Plenum Publishers, New York, New York, 2001), pp. 23–52.

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B. Engineering

1. Tools

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In December 1968, the Engineering Department sent C. G. Nottrott, Acting Area Manager of LAAO, a memo that stated, "Attached are the Secret preliminary proposal, ENG-147, and unclassified project directive and criteria drawings for the proposed Numerical Control Machining Facility at TA-21."[269]

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The attendees decided that the Director would attempt to obtain authority from LAAO and ALOO to order a Numerical Control machine. A 44-week delivery schedule had been estimated. It had originally been planned to place this machine in a modified space at DP-West (TA-21). The Engineering Department representative at this meeting proposed that a Special Fabrication and Assembly Facility be designed and built as part of DP-West.

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The CMB-11 monthly report dated June 20, 1969, indicated that a new assembly facility was to be built east of Building 5 at DP site,

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The LASL shops had offered a modified Excello Model 751 mill that could hopefully be modified for use in a glovebox enclosure. (b)(3)

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[267]D. P. MacDougall to Members, WLPC, Subject: "WLPC Meeting No. 79, November 29, 1971," ADW-168 (SRD) (November 30, 1971), p. 1, A99-019, 91-11.

[268]"TX Committee, Minutes of the 140th Meeting, October 13, 1972," TXC-140 (SRD) (October 13, 1972), pp. 5–6, B11, Drawer 52, Folder 3 of 4.

[269]Engineering Department to C. G. Nottrott, Acting Area Manager, LAAO, Subject: "Numerical Control Machining Facility, TA-21," ENG-699 (SRD) (December 10, 1968), 1 p., A99-019, 120-30.

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It was reported that the existing gauging equipment was being upgraded for use until the new equipment was available

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The CMB-11 report dated July 20, 1969, noted that the shops department personnel had modified and gloveboxed a modified tracer-controlled Excello boring machine. This unit was to be delivered to CMB-11 by August. It was stated, "This machine will provide a new and much needed machining capability for shapes and accuracy. SD will make pot chucks and templates on their tape controlled machines."[272]

By the end of August, the Model 751 Excello Tracer Mill had been installed in a glovebox in Building 5 at DP Site. Final testing of the rotary contour inspecting gauge was in progress.

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It appeared that this type of inspection might be adapted for use in a glovebox.[274]

In November 1969, LASL staff met with the Heald Machine Tool design and engineering staff to firm up the design criteria for the numerical control turning machine that had been ordered by LASL. (Heald had, in September, accepted the order from Los Alamos.[275] A two-axis, numerically controlled machine for use in a glovebox enclosure had been specified.) The LASL staff learned that the projected delivery date from Heald had slipped to September 1970.[276]

In December 1969, the CMB-11 staff reported that for measurement of the thickness of metals (specifically unalloyed Pu and 1 w/o Ga-Pu) they were evaluating the use of an eddy-current-type gauge manufactured by Laser Electronics and Scientific Corp.[277]

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The machined parts were within 0.5 mil of the part specification."[278]

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[272]"Group CMB-11 Monthly Report," CMB-11-9521 (SRD) (July 20, 1969), p. 12, A89-068, 42-3.

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[274]"Group CMB-11 Monthly Report," CMB-11-9557 (SRD) (October 20, 1969), p. 5, A89-068, 34-1.

[275]"Group CMB-11 Monthly Report," CMB-11-9537 (SRD) (September 20, 1969), p. 12, A89-068, 42-6.

[276]"Group CMB-11 Monthly Report," CMB-11-9563 (SRD) (December 2, 1969), p. 9, A89-068, 34-3.

[277]"Group CMB-11 Monthly Report," CMB-11-9568 (SRD) (December 20, 1969), p. 5, A89-068, 34-5.

[278]"Program Status Weapons Research and Development, January - March 1970 (U)," Los Alamos Scientific Laboratory report DIR-2203 (SRD) (no date), p. 36.

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[redacted] However, it was realized, as this operation was in progress, that the group had a need for more sophisticated inspection capabilities [redacted]

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The CMB-11 monthly report dated August 20, 1970, stated that the assembly and installation of a 3-axis measuring machine manufactured by Brown and Sharpe had been completed. Necessary probes, accessories, and a precision optical rotary table had been ordered. It was reported, "Methods of adapting the machine to inspection of Pu parts (with emphasis on W-Division weapons components) without committing the machine to full glove box enclosure are under study."[281]

The monthly report from CMB-11 dated November 20, 1970, noted that the group had initiated the procurement of two computer-controlled, three-axis measuring gauges. One, to be located in a glovebox, would be used for measuring Pu parts.[282]

Personnel from CMB-11 visited the Heald plant at Worchester, Massachusetts, on January 25–28, 1971, in order to perform a factory checkout before the 2-axis numerically controlled turning machine, that had been ordered by Los Alamos, was shipped. The Los Alamos group was very disappointed. They reported that during their visit, none of the five test parts had been cut to the required dimensional specifications. The CMB-11 representatives stated, "As a matter of fact, the thread cutting feature had not been tested and never did operate under automatic control during the inspection tests." The Los Alamos group added, "None of the LASL provided tapes were usable due to insufficient information supplied to us for manual tape preparation." It was clear that the machine was going to require significant modification. Moreover, additional problems were found that had not been covered in the original specifications for the machine.[283]

The Laboratory's Quarterly Status report for the period ending March 1972, reported, "Two remote-XYZ-operated Coordinate Measuring Machines purchased from Bendix have been installed by factory representatives. All phases of the factory checkout specifications were repeated after installation and were acceptable." It was noted, however, that the height of the

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281"Group CMB-11 Monthly Report," CMB-11-9672 (SRD) (August 20, 1970), p. 10, A89-068, 40-3.
282"Group CMB-11 Monthly Report," CMB-11-9711 (SRD) (November 20, 1970), p. 6, A89-068, 40-7.
283"Group CMB-11 Monthly Report," CMB-11-9723 (SRD) (February 20, 1971), pp. 7–8, A89-016, 175-2.

support frame for the rotary table restricted Z-axis motion and thus the rotary tables would require some modification by Bendix personnel. A computer program for the PDP-8 computer used for data processing had been written to gauge hemispheres by rotating them through 360° and measuring the radius at any number of locations between the equator and pole.

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~~support~~ fixtures have been made. ~~The~~ initial effort had indicated the need for better temperature control of the plutonium parts.[285]

An April 1972, report noted that at Los Alamos the program to update the machines, gaging, and pit assembling facilities for Pu components was nearing completion "with the incorporation of tracer- and numerical-controlled turning machines, rotary and three-axis gages, and a controlled atmosphere room for making assemblies."[286]

The WX-3 progress report for August 16–September 15, 1972, reported, "The Heald NC three-axis vertical lathe is now equipped with a precision bracket that can be locked either to hold an air motor in a vertical position or, by virtue of a well designed swivel joint, to hold the motor in a horizontal position

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[285] "Quarterly Weapon Research and Development Status Report, April 1–June 30, 1972," CMB-1893 (SRD) (July 14, 1972), p. 14, A89-056, 24-9.

[286] "Plutonium Research Programs, FY 1972," Plutonium Research Coordinating Committee, U.S. Atomic Energy Commission report SMA-470-746 (SRD) (April 1972), p. 18, B11, Drawer 47, Folder 1 of 1.

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3. Reservoir Designs to Provide Minimum Helium in the Boost Gas

In a March 1969 memo, primary designer R. Canada outlined the problems that were the result of the formation of ^{3}He from the decay of the tritium used in the primary's boost gas.

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The yield of a boosted primary is degraded as tritium is converted to ^{3}He both by the loss of the source of 14-MeV neutrons and also by the decrease of the pre-boost multiplication rate caused by the high cross-section for neutron capture which is characteristic of ^{3}He." He went on to add, "In a conventional boosted single-stage device the tritium produced by ^{3}He appears too late in the bomb's explosion to contribute to the yield, and the temperature does not get high enough to produce significant ^{3}He + D fusion."[293]

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[293] R. Canada to Distribution, Subject: "^{3}He in Weapons," W-4-2518 (SRD) (March 10, 1969), 5 pp., A99-019, 199-13.

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4. Detonators

a. Test Firing Data

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Historically, various types of detonators ~~have~~ been used, depending upon the type of primary, in the NTS test program. If one type of detonator had been used and it was decided to change to another type of detonator in a similar shot, it was of course necessary to understand any change in the behavior of the new detonator. One way to test any change was to fire the different types of detonators in field tests at Los Alamos.

The GMX-3 progress report for March 16 through April 15, 1969, noted that a request had been given to GMX-8 for a test fire that would compare the 1E30 detonator in a PBX 9407 pellet with the MC-1991 detonator. On April 18, GMX-8 personnel fired the shot. [Author's note: The GMX-8 firing pads were at Kappa site, TA-36.] The GMX-3 progress report stated, "The trace from the 1E30 is not identical with that from the MC-1991; it now remains for us to determine the difference in wave shape and to assess its effect on the system."[316]

Apparently, GMX-8 personnel fired yet another shot. The GMX-3 progress report for May 16 through June 15, 1969, reported that the trace shapes were interchangeable.

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[316] "Group GMX-3 Progress Report (U), March 16 through April 15, 1969," GMX-3-7818 (SRD) (no date), p. 10, A86-016. 32-16.

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4. Detonators

a. Test Firing Data

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Historically, various types of detonators have been used, depending upon the type of primary, in the NTS test program. If one type of detonator had been used and it was decided to change to another type of detonator in a similar shot, it was of course necessary to understand any change in the behavior of the new detonator. One way to test any change was to fire the different types of detonators in field tests at Los Alamos.

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[316] "Group GMX-3 Progress Report (U), March 16 through April 15, 1969," GMX-3-7818 (SRD) (no date), p. 10, A86-016. 32-16.

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Test Fire Data for NTS

B. Pruit Ginsberg, who came to the Laboratory in 1970 to work in GMX-7, recalls that his group leader, Robert L. Spaulding, was a very particular person; his attitude was transmitted to every member of his group. Before each NTS test, several activities took place. Group members of GMX-7 would perform tests to make sure that their firing circuits and detonators were performing properly. These were the confirmation tests. Next Spaulding would send to the staff at PHERMEX a very complete layout of the firing and detonation circuits and all the required specifications. The PHERMEX group could then use this information in setting up any hydro shot that was to be completed for the forthcoming NTS test. Finally, a shot timing memo would be sent out from GMX-7 for use in the NTS event.[319]

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Included are the types of firing units, firing cables, signal cables, and the firing voltage, as well as the type of detonators and the detonator lot used in the firings. Firing data are reported, one for the shot and one for a backup shot.]

b. Early Work Applicable to the 1E33 Detonator Development

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Instead, the detonator group would develop a new type. [Author's note: It will be noted that the 1E30 was an important evolution from earlier detonators in the fact that it was much smaller. Its development, which Ginsberg recalls as being meticulously done, was an important precursor program for the 1E33.]

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[319] B. Pruit Ginsberg, personal communication (SRD) (January 29, 2003).

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Taylor in his history has noted that the "new detonator cable developed by WX-7 was most beneficial."[324]

Today the 1E33 detonator is still in use in the W76. Ginsberg has reported that these detonators show no signs of deterioration with age.[325]

5. Engineering Computer Codes

The WX-3 progress report for November 16 through December 15, 1972, stated in regard to the Mk 400 program, "The SABOR-DRASTIC computer code is now operating correctly for the combined RV/WH models and results were obtained for one of the support schemes."

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By early 1973, the engineers had begun to consider using, for lateral support, a light foam over the entire length of the WH. The results from the SABOR-DRASTIC code runs for this type of mounting were encouraging.[327]

6. Assembly

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[324] John W. Taylor, "The W76 Program: An X-ray View (U)," M-2 TM253 (SRD) (January 8, 1976), p. 70.
[325] B. Pruit Ginsberg, personal communication (SRD) (January 29, 2003).

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[327] "Group WX-3 Progress Report (U), January 16 through February 15, 1973," WX-3-73-97 (SRD) (no date), p. 19 A86-016, 275-1.

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C. Vulnerability

1. Considerations

As the USSR began to develop missiles that carried nuclear weapons, military planners in the United States became concerned that these types of weapons could be used as defense weapons against incoming nuclear-armed missiles from the United States. The question then arose as to how to "harden" the U.S. reentry vehicles and warheads to minimize the impact of this type of Soviet defense.

In addition, it became technically possible in the United States to have one missile carry more than one warhead. As these warheads were released and detonated over a target(s), and if the offensive warheads were detonated too close together during a similar time period, the radiation released from one would affect the others. Again, there was the question of how best to deploy these types of warheads and how to "harden" each warhead from the effects of the others (fratricide).

In response to these problems, scientists in the U.S. weapon complex developed special materials and engineering features designed to minimize the damage (both from radiation and from the shock and heat produced by the interaction of radiation with materials) to a nuclear warhead

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~~It was necessary to~~ test these designs and materials to see if they met the design objectives. The tests included field-type tests and tests at NTS. In addition, computer codes were developed, based on experimental data, to predict the behavior of components under adverse conditions.

Several types of field tests were employed. In one type of test, shocks were sent into the special materials to study their behavior. Other tests measured the effects of high temperature and similar adverse environments. In another type of test, radiation from a radioactive source, an accelerator, critical assembly, or reactor was used to expose the device to neutrons or x-rays. The type and amount of radiation that could be delivered was dependent upon the irradiating source. These field tests were never able to duplicate an actual exposure environment during deployment.

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The most complex and expensive tests employed were the NTS-type tests. These tests were used to mock-up, in so far as possible, the actual conditions that a warhead might be subjected to. In the following section these vulnerability tests will be briefly described in terms of the specific tests that were relevant to the pre-Phase 3 development of the XW76.

2. NTS Vulnerability Tests

a. Description

NTS vulnerability tests were "effects" tests where the output (neutrons/x-rays) from a detonated nuclear device was used to determine how various weapons, weapon materials, and engineering features would respond should they encounter a hostile environment. This environment might result from the nearby detonation of a nuclear ABM sent by the targeted country or from close detonation of warheads from a U.S. missile in a MIRVed type of deployment. The hostile environment might be encountered at high altitude or near the target.

In this type of NTS test, the sponsoring agency specified what type and level of radiation was required for their experiments. Participating agencies could also specify what exposure would be most useful in their experiments.

Many of the vulnerability tests were sponsored by the Department of Defense/Defense Atomic Support Agency (DOD/DASA). These tests usually had, as noted in Chapter I, double names. Some were sponsored by a weapon laboratory. The sponsoring agency's project managers decided (based on what they wanted in terms of radiation output) on a suitable device. The laboratory (Los Alamos or Livermore) that had designed this device was then asked to provide the device and to assume responsibility for emplacement and detonation of the device. In general, this device was usually a design that had already undergone a previous test(s) where the output radiation had already been determined. If a tested device were not available, a preliminary test to determine specific output might take place at NTS. In addition to supplying and detonating the device, the scientists at the specified laboratory were also responsible for the device diagnostics. In addition, certain diagnostics, for example seismic yield, were done on a routine basis by outside agencies.

Once the nuclear device with its known output had been specified, suitable stations at various distances from the device were set up in the facility in which the experiment was to take place. (Because of the layout required, vulnerability tests were usually done in tunnels at NTS.) The necessary shielding was installed. Instruments to measure the flux of the radiation falling on the samples to be tested were designed, built, and installed. The pieces of equipment or samples for which exposure data were desired were inserted at the specified locations. Special closure assemblies, used to close off the affected region and in theory, prevent bomb debris from spreading into the main tunnel/environment, were designed and installed.

The test configuration with its tunnels, test stations, access holes, and other required facilities could be extremely complex.

(b)(3) The zero room housed the detonated device, firing stand, firing and diagnostics equipment, and front-end closures. (b)(3)

Another line of sight extended from the zero room into an alcove designated "M." The line of sight for the major experimental areas was constructed in a main

drift 925 ft in length. A further 30-foot extension consisting of an arched tunnel housed alcove L. As shown in Figure IV-4, several shafts were used to access the various areas.[333]

John Hopkins, former Test-Division leader, has commented that each layout for a vulnerability test was different. However, all were major efforts in terms of construction and instrumentation.

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b. Test List

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The test layout was designed with three experimental stations in the exposure pipe. An aluminum flux screen was used to cut off, at these stations, x-rays below 10 keV. The latter two stations also included the use of a polyethylene filter to further reduce the flux.

Not only were the various engineering/test groups at Los Alamos responsible for providing the nuclear device and diagnostics, but personnel from J-14 and W-7 along with personnel from EG&G were also responsible for x-ray effects measurements.[337]

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In another Los Alamos experimental set-up, ¾-inch-diameter cylinders, made up of disks of various materials with different thickness layers, were exposed. It was reported that the data obtained in this experiment would allow for the determination of damage thresholds. Another experiment was designed to investigate the thermal limits in various material interfaces. These interfaces included various cross sections of radiation case materials, high-Z loaded plastics, and cylinders of HE.

A listing and description of additional experiments is available in the cited references.[347] Just after the test had been completed, the GMX engineers reported that good data had been obtained; however, the temperatures had been lower than expected.[348]

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[347] John H. McQueen to Cdr. D. D. Swift, TC/DASA, Subject: "Final Report of LASL Data from Experiments Aboard the Hudson Seal Event," J-DO Tech (SRD) (April 21, 1969), 19 pp., A99-019, 265-13. "Program Status Weapons Research and Development, July – September 1968, Part 2 of Two," Los Alamos Scientific Laboratory report DIR-2142 (SRD) (no date), pp. 25–26.

[348] "Group GMX-3 Progress Report, September 16 through October 15, 1968," GMX-3-7455 (SRD) (no date), p. 15, A86-016, 32-10. "W-Division Quarterly Status Report, July 1, 1968 through September 30, 1968, Part 2 of Two," W-2145 (SRD) (October 15, 1968), pp. 41–42, A86-016, 242-7.

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The results from the material experiments were noted to have been generally successful. Additional information is available in the cited reference.[361]

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In addition to the LASL experiments, plans were made for the extensive use of the test facility by other organizations.

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Preparations for the test began at Los Alamos almost two years before the test would actually take place.

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[394] "W-Division Quarterly Status Report, April 1, 1970 through June 30, 1970," W-2264 (SRD) (July 15, 1970), pp. 17~~–24, A86-016, 242-13.~~

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During the summer of 1971, the Los Alamos group began working on their own setup for a full vehicle experiment

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In the spring of 1972 the engineers completed output calculations in order to verify the time history of the flux out of the exposed device and the exposure level at the 1,900-ft station.[430]

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Before the test, the Los Alamos field test groups had installed a trailer containing sufficient equipment to support approximately seventy channels of measurement instrumentation. After the test, it was reported that all the LASL instrumentation had recorded data.[432]

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[430]Leslie M. Redman and Cecil C. Carnes, "Quarterly Status Report on Weapons Research and Development (U), for the Period Ending March 31, 1972," Los Alamos Scientific Laboratory report LA-4965-PR (SRD) (June 1972), p. 71.

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[432]Luella M. Button, "Quarterly Summary of Field Testing and Instrumentation Development (U), for the Period Ending September 30, 1972," Los Alamos Laboratory report LA-5082-PR (SRD) (October 1972), p. 8.

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In the spring of 1973, the Los Alamos groups installed their experiments in the number-2 test chamber and completed the installation of all diagnostic cables.[445] A 32-channel multiplex system was designed and built to collect 30 channels of thermocouple data.[446]

After the detonation of the device, the multiplex unit collecting data from the thermocouples operated until the experimental wiring was destroyed after 100 milliseconds. The thermocouple data indicated that the temperatures measured at the outer surface of the HE had been higher than predicted. Nevertheless, a PBX 9501 pellet embedded in the mock HE system showed no evidence of decomposition.[447] (Later, it was reported that perhaps the actual temperatures had been lower than those measured.[448])

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[445]Luella M. Button, "Quarterly Summary of Field Testing and Instrumentation Development (U), for the Period Ending March 31, 1973," Los Alamos Scientific Laboratory report LA-5268-PR (SRD) (May 1973), p. 1.

[446]Luella M. Button, "Quarter Summary of Field Testing and Instrumentation Development (U), for the Period Ending June 30, 1973," Los Alamos Scientific report LA-5350-PR (SRD) (July 1973), p. 1.

[447]"Group WX-3 Progress Report (U), July 16 through August 15, 1973," WX-3-73-439 (SRD) (no date), p. 4, A86-016, 275-7.

[448]"Group WX-3 Progress Report (U), September 16 through October 15, 1973," WX-3-73-539 (SRD) (no date), pp. 4, 6, A86-016, 275-9.

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3. Calculations

The relevant literature of the late 1960s and early 1970s time period indicates that a very active program was carried on at Los Alamos to calculate the effects of x-rays and neutrons on the Los Alamos weapon designs. These calculations were then compared with the experimental results obtained in the NTS vulnerability tests.

It was reported that the most useful way of expressing the neutron vulnerability of a nuclear weapon was through use of an "F-number." These were customarily expressed in terms of the average number of reactions per kg of material per unit neutron fluence on the exterior of the carrying vehicle. The literature of the period extensively reports on the calculations of F-numbers.

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CHAPTER V. WEAPON PROGRAMS AND CHANGES IN THE STOCKPILE: 1965–MAY 1973

A. Phase 3 Programs at Los Alamos

1. Assignments

a. Phase 3 Programs Entering the Stockpile

During the period 1965–May 1973, the Los Alamos Scientific Laboratory weapon development and design group members were responsible for several Phase 3 weapon programs. [The Phase sequence for weapon programs is noted in Chapter I.] For those weapons that entered the stockpile, the specific weapon program, the date of the Phase 3 award, and the date of the attainment of Phase 6 are as follows:[1]

Weapon Program	Phase 3	Phase 6
B61 Mod 0	June 1963	January 1967
B61 Mod 1		February 1969
B61 Mod 2	August 1971	June 1975
B61 Mod 3	March 1972	October 1979
*W66**	*January 1968*	*October 1974*
W69	January 1967	February 1972
W72	May 1969	September 1970
* Never deployed to the field[2]		

b. Canceled Phase 3 Assignments

In addition to those weapon programs assigned to Los Alamos that were in or went into Phase 3 during the 1965 to 1973 period and entered the stockpile, several Phase 3 programs were assigned to Los Alamos but were later canceled. These were the XW64, XW67, XW73, and XW74.[3]

c. Discussion

The Phase 3 weapon programs under development at Los Alamos from 1965 through May 1973 will be discussed in the following sections. Each section will cover a specific weapon.

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[1] "FY 1994 Annual Weapons Program Report," DOE Albuquerque Operations Office report (SRD) (October 1, 1994), pp. 25–26, 301, 309, 326.

[2] "FY 1994 Annual Weapons Program Report," DOE Albuquerque Operations Office report (SRD) (October 1, 1994), p. 301.

[3] Betty L. Perkins, "Why Nougat? (U)," Los Alamos National Laboratory report LA-12950-H (SRD) (November 1, 1995), p. A-3.

2. Weapon Programs

a. B61

While the Phase 3 assignment for the B61 Mod 0 was received by the Los Alamos Scientific Laboratory in 1963, the Los Alamos weapon groups were going to find that they would have an extended development program for this weapon. The B61 would go through many models and deployment objectives over a period of many years. Several Mods of this bomb, in modified designs from the ones that were first developed, are still in the U.S. nuclear weapon stockpile.

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The B61 Mod 0, 2, and 5 bombs would be carried by U.S. Navy A-6E and F/A-18A/C/D aircraft. These bombs would also be carried by U.S. Air Force F-16 A/B/C/D and F-111 D/E/F aircraft. The later Mod 3, 4, and 10 variations would be carried by U.S. Air Force F-16 A/B/C/D and F-111 D/E/F aircraft as well as F117-A aircraft. The Mod 3, 4, and 10 bombs would also be carried on NATO F-16 A/B aircraft and on Tornado aircraft. A recent version (Mod 7) is carried on the Air Force B-2A and B52-H. As the different Mods were introduced into the stockpile, many additional safety features would be included. The early Mod 0-Mod 2 designs discussed in this section have been retired from the stockpile or converted.[4]

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The B61 Mod 0 and Mod 1 weighed 715 lb and had a diameter of 13.3 inches and a length of 141.6 inches. The B61 Mod 0 first entered the stockpile in January 1967.

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[4] "FY 1994 Annual Weapons Program Report," DOE Albuquerque Operations Office report (SRD) (October 1, 1994), pp. 25, 29.

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In the late 1960s there was increasing concern over the safety and security of nuclear weapons.

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As previously noted, after production of the Mod 0 and Mod 1, other Mods of the B61 were planned. At the January 14, 1972, meeting of the TX Committee it was reported that when the B61 went "back into production the next time," there might be problems because some of the hardware companies had gone out of business or did not want the AEC contracts.

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b. XW64

In May 1964, the Military Characteristics for nuclear warheads for the Lance Missile system were issued. This missile was to be a surface-to-surface missile for use by the Army. Both Los Alamos and Livermore submitted proposals for this warhead. As it would turn out, both Laboratories would initially receive the authorization to proceed. The XW64 was the nomenclature given to the Los Alamos design; XW63 was the nomenclature given to the Livermore design.

Los Alamos received the authorization to proceed with the development of the XW64 on July 20, 1964. (b)(3) However, the initial authorization was soon withdrawn. Attempts were made by the Los Alamos management in 1966 to have the program reactivated.[77] But neither the XW63 nor the XW64 was ever produced.

The final warhead, that provided a nuclear capability for the Army's surface-launched guided missile (MGM-52C) known as Lance, was the W70. The Phase 3 assignment for the W70 warhead was given to Livermore in April 1969

(b)(3)

c. W66

The W66 was a two-stage thermonuclear warhead designed for use on the Sprint missile. This missile was a short-range, low-altitude, quick reaction intercept missile. Therefore, the missile had high launching and maneuvering accelerations and a very short reaction time between launching and the firing of the warhead.

(b)(3)

The Sprint missile/warhead was part of the Safeguard weapon system.

The AEC laboratories originally received the Phase 3 authorization for the development of the warhead for the Sprint missile system in September 1965.

(b)(3)

[77]N. E. Bradbury, Los Alamos Scientific Lab., Los Alamos, N.M. to Brig. Gen. Delmar L. Crowson, DMA, USAEC, Wash., D. C., DIR-2017 (CRD) (February 14, 1966), p. 1, A99-019, 217-7.

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(b)(3)

UNCLASSIFIED

~~SECRET/RD~~

(b)(3)

UNCLASSIFIED

~~SECRET/RD~~

The W-Division quarterly status report for January 1 through March 31. 1967. indicated that the pit system for the XW67 warhead was in the design phase.

(b)(3)

The W-Division quarterly report for January through March 1967 reported that environmental tests were being planned. (b)(3) It was noted that the development of the XW67 was felt to be on schedule.[128]

The W-Division quarterly report for April 1 through June 30, 1967, notes that development work was continuing. Extensive structural analysis on the design was being performed.[129] During the summer of 1967, the engineers found that the XW67 prototype would need to be reengineered; the proposed design did not meet the load requirements.

(b)(3)

[128] "W-Division Quarterly Status Report, January 1, through March 31, 1967, Part 2 of Two," W-2020 (SRD) (April 14, 1967), pp. 15, 28-30, A86-016, 242-1.

[129] "W-Division Quarterly Status Report, April 1, 1967 through June 30, 1967, Part 2 of Two," W-2035 (SRD) (July 17, 1967), pp. 2–3, 23, A86-016, 242-2.

(b)(3)

e. W69

(b)(3)

This retired warhead entered the stockpile in 1972 (b)(3)

The W-Division quarterly status report for January 1 through March 31, 1967, indicates that the XW69 warhead was now in Phase 3. By March, a preliminary design had been released for warhead development scheduling. (b)(3)

The next quarterly report from W-Division (April 1, 1967 through June 30, 1967) indicates that the development effort on the XW69 was continuing

(b)(3)

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g. XW73

The Condor was a proposed Navy missile. It was to be a TV-guided, rocket-powered, air-to-surface missile. The warhead for this missile was designated the BA73. Initially, two versions of the warhead were to be provided.

(b)(3)

The initial plans for the warhead were to use a slightly modified W69.[182] The Condor Development Authorization notice for the nuclear warhead section is dated July 15, 1969.[183] However, Giller, in a November 24, 1969, TWX to the Laboratory, noted that the Initial Operational Capability (IOC) date for the Condor warhead had been delayed. The Laboratory was instructed to study all the possible alternatives in the design and development of nuclear systems for the Condor.[184]

(b)(3)

A letter dated July 13, 1970, to the Chairman of the AEC from the DDR&E (Director, Defense Research & Engineering) states, "Recent program reviews have resulted in a decision to delay a commitment to production of the Condor missile system until the completion of system engineering development and operational evaluation. This action will also delay the Navy support for the nuclear warhead development program until approximately September 1972 when further Condor program decisions can be expected." The letter also notes, "It may be prudent for the AEC to stop all nuclear Condor development activity until a Navy commitment to production is made." However, it did appear that some developmental activities might have to continue if the Condor warhead were to become operational as early as January 1975.[187]

(b)(3)

182"Program Status Weapons Research and Development July– September 1969 (U)," Los Alamos Scientific Laboratory report DIR-2187 (SRD) (no date), p. 61. "W-Division Quarterly Status Report, July 1, 1969 through September 30, 1969," W-2217 (SRD) (October 15, 1969), p. 27, A86-016, 242-11.

183H. C. Donnelly, Manager, Albuquerque Operations Office, AEC to N. E. Bradbury, Director, LASL and J. A. Hornbeck, President SLA, Subject: "Condor Development Authorization," (CRD) (July 15, 1969), 2 pp., A99-019, 198-11.

184*USAEC, Edward Giller, Wash., D.C. to USAEC, H. C. Donnelly (SRD) (November 24, 1969), 3 pp., A99-019,* 218-18.

(b)(3)

187USAEC, Edward B. Giller, Wash., D.C. to AN3, USAEC, H. C. Donnelly, Albuquerque, N.M. et. al., (CRD) (July 31, 1970), 2 pp., A99-019, 39-7.

(b)(3)

The AEC and the Navy then apparently decided to suspend specific warhead development until the Condor missile was farther along in its development. It was felt that not to do so might result in a "less than optimum nuclear warhead" to interface with the missile. In October 1970, it was reported that the W73 was in a suspended Phase 3. Future development efforts were uncertain.[189]

(b)(3)

[189]"Weapons Program Study and Development Report," Headquarters Field Command, Defense Atomic Support Agency, Sandia Base, Albuquerque, New Mexico report FC10700038 (SRD) (October 1, 1970), p. 26.

(b)(3)

(b)(3)

The Advanced Planning Document for the W73 was issued in October 1971.

(b)(3)

The third quarter report for 1972 from the Laboratory states, "The insertable-capsule (IC) concept has recently interested the AEC and DoD for several convertible warhead applications. The convertible WH uses a conventional HE warhead, which, if necessary can be converted to a nuclear warhead by inserting a fissionable core. ...Some of the more interesting applications are for Harpoon, the Modular Guided Glide Bomb, Condor, the Mk 48 and Mk 46 torpedoes, and the Mk 84 bomb." It was also noted, "LASL is working on a proposed program to field a nuclear test of a device representative of the IC, convertible-warhead concept before June 30, 1973."[196]

Despite the initial warhead development program discussed briefly in the previous paragraphs, the warhead was never produced.

h. XW74

The XW74 was an Army-Navy-proposed 155-mm projectile. The project was canceled in June 1973 at the end of the Phase 3, which had been awarded to Los Alamos.

The Laboratory status report for weapons for the period January–March 1969 notes that a Phase 2 feasibility study for a new 155-mm nuclear round for the Army was nearing completion. Two designs had been proposed.

(b)(3)

(b)(3)

[196]Leslie M. Redman and Cecil C. Carnes, Jr., "Quarterly Status Report on Weapons Research and Development for the Period Ending September 30, 1972 (U)," Los Alamos Scientific Laboratory report LA-5130-PR (SRD) (January 1973), p. 72.

(b)(3)

(b)(3)

The Laboratory's status report for that period gives detailed information on the material problems that would have to be solved should the design be a successful one.[199]

The Phase 3 for the W74 warhead was initiated on October 28, 1969.[200] The Laboratory was assigned engineering development responsibility on February 24, 1970.[201]

The Laboratory status report for January–March 1970 reports, "Authorization to proceed with a Phase 3 development program for a 155-mm AFAP [Artillery Fired Atomic Projectile] was received from DMA on February 24. The list of approved Military Characteristics and the *Army Stockpile to Target Sequence were received in early March. The Army nomenclature for* the AFAP is XM-517. AEC nomenclature for the nuclear warhead is W74.

(b)(3)

The January 1 through March 31, 1970, W-Division report indicates that engineering design and field test efforts were continuing for this project.

(b)(3)

During the spring of 1970, design and procurement of components for the local hydrodynamic shots was reported as proceeding on schedule. Special high-pressure materials were undergoing development.[204]

During the summer of 1970 various specific pit designs were studied for use in the XW74.

(b)(3)

A structural test plan was outlined. Stress analysis was being performed using the

(b)(3)

[199] "Program Status Weapons Research and Development October – December 1969 (U)," Los Alamos Scientific Laboratory report DIR-2195 (SRD) (no date), p. 65.

[200] "Nuclear Technology and Analysis Report (U)," Field Command Defense Nuclear Agency, Kirtland Air Force Base, New Mexico 87115 report HQDNA-185M, (SRD) (August 1, 1972), p. 32, B11, Drawer 57, Folder 1 of 2.

[201] USAEC, Edward B. Giller, Wash., D.C. to C13, N. E. Bradbury, LASL, Los Alamos, N.M., BW3, M. M. May, LRL. Livermore. Calif. (CRD) (February 24, 1970), 1 p., A99-019, 198-12.

(b)(3)

[204] "W-Division Quarterly Status Report, April 1, 1970 through June 30, 1970," W-2264 (SRD) (July 15, 1970), p. 40, A86-016, 242-13.

(b)(3)

SAAS II code

(b)(3)

~~During the~~ first quarter of 1971 engineering design work continued. The status report from W-Division for January 1 to March 31. 1971 notes that the examination of alternate case materials was continuing.[207]

(b)(3)

The Laboratory's status report ending March 1971 indicates that two concepts relevant to nonviolent disablement had been investigated theoretically. The report also notes, "The AEC production schedule for the W74 has slipped because of funding problems. The date of the Phase 5 is now December 1974 and for the Phase 6 is March 1975."[209] The Laboratory's status report ending June 1971 reports that weapon denial schemes were continuing to be investigated.

(b)(3)

[207] "W-Division Quarterly Status Report, January 1, 1971 through March 31, 1971," W-2318 (SRD) (April 15, 1971), pp. 19–20, A86-016, 242.16

(b)(3)

[209] "Quarterly Status Report on Weapons Research and Development for the Period Ending March 31, 1971 (U)," Los Alamos Scientific Laboratory report LA-4680-MS (SRD) (May 1971), pp. 38–39.

(b)(3)

(b)(3)

Engineering design and test activities had also continued during the summer.

(b)(3)

In early November the design/engineering teams had begun the next iteration towards producing a weaponized device.

(b)(3)

(b)(3)

However, these tests were very useful in guiding the design of the XW74.[229]

(b)(3)

[229] R. K. Osborne and M. T. Thieme, "Theoretical Design of Implosion Weapons, 1959-1980 (U)," *Defense Research Review*, UCRL 53880-4-2 ~~(SRD) (July 1992)~~, p. 72.

(b)(3)

(b)(3)

[. The question of what was the most suitable design to use in the "revised" XW74 was discussed during the September 25, 1972, WLPC meeting.]

(b)(3)

The device is shown in Figure V-4. Additional information is available in the cited

(b)(3)

references.[240]

(b)(3)

However, the initial firing tests had been fairly conservative as to the structural design, and therefore it was not known what the exact modifications would have to be.[242]

(b)(3)

[242]"Military Applications Planning Committee, Minutes of the 17th Meeting, December 15, 1972," TDW-48 (SRD) (December 15, 1972), p. 1, B11, Drawer 53, Folder 1 of 2.

(b)(3)

It was to be the final proof test of the W74.[246] This test never took place.

The XW74 program was cancelled in June 1973.

3. Conclusions Concerning the Phase 3 Program

a. Development Problems

The brief summaries of the Los Alamos Phase 3 programs reported in the previous sections of this chapter demonstrate that even after a Phase 3 award had been made, the development program did not necessarily go smoothly. There were many tests where the test results were not the predicted results. In several cases, a large number of tests were required before an adequate design was available for the stockpile.

The Phase 3-to-stockpile sequence was not an easy, predictable one.

b. Primary Considerations

(b)(3)

It is not surprising that the Los Alamos Laboratory during this period did not receive a Phase 3 assignment for a strategic missile system that used MIRVed warheads.

c. Focus of Work

The reader will also have noted, in the discussion of the Phase 3 weapon programs at Los Alamos, that in the early 1970s the Phase 3 work was becoming less and less of the total work load. Except for the continuing work on the B61, either (1) the weapons had successfully gone to the stockpile or would soon go to the stockpile, or (2) the Phase 3 work had been terminated or soon would be terminated.

(b)(3)

[246]B. Heil, W-9 to WPRC Members, Subject: "FY 1973 NTS Tests," W-9-1351 (SRD) (February 23, 1972), p. 22, B11, Drawer 51, Folder 3 of 3.

The completion/cancellation of the Phase 3 programs without receiving new Phase 3 programs would have meant that a work reassignment would have been required for many Laboratory employees. A large number of persons were employed either directly or indirectly in a Phase 3 program. Not only were the primary/secondary design groups and NTS test groups involved, but also the field test groups, the engineering development and design groups, and the materials science groups. There were in addition many persons at the Laboratory who served to track the efforts and coordinate the work with the staffs at the weapon facilities (such as Sandia, Rocky Flats, Pantex, and Oak Ridge) as well as with the Military.

d. Status Symbols

In a sense, receiving an assignment of a Phase 3 program was a status symbol. It indicated that that laboratory was making a valuable contribution to maintaining for the United States a modern, nuclear weapon stockpile.

This status symbol was important politically. It was also important for maintaining high morale among those involved in the weapons program.

B. Advanced Development and Pre-Phase 3 Programs

During this 1965–early 1973 period, in addition to Phase 3 programs assigned to Los Alamos, the members of the various weapon groups were also working on programs that were in the Phase 1 or 2 stage. The members of these groups were also involved in a large number of advanced development projects. Many of the programs/projects were canceled before they reached a Phase 3 designation. However, as a historical background for the XW76 program, it is important to understand these programs.

The following discussion of advanced development and pre-Phase 3 programs will focus on projects under consideration in a particular year. [Author's note: These projects, especially those in advanced development, have been difficult for this author to track because the programs often changed names, changed objectives etc. The discussion presented in the following sections is by no means complete.]

The Mk 18 and Mk 400 programs are, however, not included. These were specific precursor programs to the XW76. Because of their importance in the development of the XW76, they will be described in detail in the following chapter. The small primary development program, previously described in Chapter II, will also not be included.

1. 1965

(b)(3)

(b)(3)

Sprint

(b)(3)

Thumbelina

(b)(3)

Mk 17 Warhead and the Increased Penetrability Program

(b)(3)

Other Applications for High-Yield Weapons

Other applications for these high-yield types of weapon designs included use in the Advanced Manned Strategic Aircraft [AMSA], the ICBM-X, and the Poseidon warhead. None of these systems had, at that time, been approved.[254]

(b)(3)

[254] "LASL Program for Fiscal Years 1966-1967," DIR-1980 (SRD) (May 25, 1965), p. 40.

(b)(3)

Short Range Attack Missile (SRAM)

(b)(3)

Improved Pershing

(b)(3)

Follow-On Lance

After the award of the Phase 3 for the Lance missile warhead (W70) to Livermore, the Military requested, as a follow-on, a study of a warhead for the Lance and a warhead for an ABM that had low requirements of reactor products

(b)(3)

(b)(3)

d. Single-Stage Weapons
Primary

(b)(3)

SADM [Special Atomic Demolition Munition]

(b)(3)

e. Projectiles
175-mm Shell

(b)(3) [264] This nuclear device was to be a close ballistic match to the conventional high-explosive round.

8-in. Shell

(b)(3)

(b)(3)

[264] "LASL Program for Fiscal Years 1966-1967," DIR-1980 (SRD) (May 25, 1965), p. 42.

(b)(3)

Improved Small Atomic Demolition Munition (SADM)

(b)(3)

e. **Projectiles**
175-mm and 8-in. Projectiles

(b)(3)

It appeared that a redesigned 8-in. shell with the same ballistic characteristics as the conventional 8-in. shell or a rocket-assisted 8-in. shell could also be developed.

There had been a lack of a specific interest by the Army for either the 175-mm or 8-in. shell projectiles. The Laboratory's yearly report noted that the Los Alamos groups had reduced their effort on these types of designs to "essentially zero."[287]

155-mm Projectile

(b)(3)

[287]"LASL Program for Fiscal Years 1967-1968," DIR-2029 (SRD) (no date), p. 33.

(b)(3)

3. 1967

a. (b)(3)

Spitfire (Spartan)

By 1967, Spitfire had evolved into a program called Spartan. A report dated February 7–8, 1967, reported, "The present LASL SPITFIRE Test Program is directed toward developing a warhead for the SPARTAN Missile. To shorten the warhead development time scale, the tests are being performed in as near a weaponized configuration as possible."[290] (This program would later become part of the Safeguard program described in a following section.)

(b)(3)

A memo from Jane Hall noted that during the October 25, 1967, WLPC meeting Bradbury and Agnew had reported on the October 23, 1967, Spartan meeting that had been held in Washington. The two had reported that General Giller (Assistant General Manager for Military Application) had indicated that he expected LASL and LRL to propose a pie-split in the Spartan program.

(b)(3)

[290] "Minutes of the First Meeting Spartan Ad Hoc Interface Working Group," (SRD) (February 7-8, 1967), p. 13, A99-019, 227-18.

(b)(3)

(b)(3)

A Sandia paper dated November 16,1967, noted that a follow-on Spartan program was also being considered.

(b)(3)

The Sandia paper stated, "This Follow-on Spartan will supplement, but not replace the Spartan."[295]

It appears that by December 1967, the management at the Laboratory was beginning to consider the fact that the LASL would probably be assigned the Sprint program and Livermore would receive the Spartan (b)(3)

Sea-Based Ballistic Missile Intercept System

Also under consideration at that time was the design of a warhead for the Sea-Based Ballistic Missile Intercept System (SABMIS).[297]

Scampi

(b)(3)

[295]"Follow-On Spartan," Sandia report RS 5624/52 (SRD) (November 16, 1967), p. 1, A99-019, 227-18.

(b)(3)

[297]"LASL Program for Fiscal Years 1968-1969," DIR-2081 (SRD) (May 21, 1967), p. 19.

(b)(3)

[298]"LASL Program for Fiscal Years 1968-1969," DIR-2081 (SRD) (May 21, 1967), pp. 19–20.

(b)(3)

This effort will be discussed in the final chapter of this report.[302]

(b)(3)

Walleye

There was a Phase 2 study of a warhead for the Walleye glide bomb.

(b)(3)

SAM-D

A Phase 2 study for a primarily mobile field Army air defensive system was expected. This was to be called the SAM-D missile.[303]

e. Projectiles and Earth-Penetration Weapons

175-mm and 8-in. Shells

(b)(3)

However, it was reported, "...lack of specific interest by the Army has reduced this activity to essentially zero. A hardware program which uses 8-in. projectiles in earth penetrating weapons is being done in collaboration with the Sandia Corp."[304]

155 mm

There continued to be interest in the 155-mm projectile program.[305]

(b)(3)

After evaluation of the data, it appeared that further engineering improvements were needed.[307]

[302] "LASL Program for Fiscal Years 1968-1969," DIR-2081 (SRD) (May 21, 1967), pp. 20–21.
[303] "LASL Program for Fiscal Years 1968-1969," DIR-2081 (SRD) (May 21, 1967), p. 21.
[304] "LASL Program for Fiscal Years 1968-1969," DIR-2081 (SRD) (May 21, 1967), p. 23.
[305] "*W-Division Quarterly Status Report, April 1, 1967 through June 30, 1967*, Part 2 of Two," *W-2035 (SRD)* (July 17, 1967), pp. 1–15, A86-016, 242-2.

(b)(3)

[307] "W-Division Quarterly Status Report, October 1, 1967 through December 31, 1967, Part 2 of Two," W-2084 (SRD) (January 15, 1968), pp. 17–20, A86-016, 242-4.

(b)(3)

Bayonet

Reported in the third quarter report for 1967 from W-Division was a proposed program called Bayonet. The report states, "Bayonet is a program to determine the feasibility of using a nuclear warhead in an air-dropped weapon which can be exploded after the weapon has impacted and penetrated the ground." The warhead compartment had a diameter of approximately 6.5 inches. The report from W-Division also indicates that the first Bayonet warhead had been drop-tested at Tonopah.[309]

The fourth-quarter report from W-Division notes that the second complete Bayonet assembly had, in October 1967, been drop-tested at the Tonopah Test Range. The missile had not penetrated properly, and the warhead had been damaged. It was stated that Sandia Corporation would correct the missile deficiencies before additional drop tests were made. However, based on the available data, it appeared that if the missile survived, the warhead would survive and would be able to function after impact.[310]

f. Nonnuclear Kill

(b)(3)

4. 1968

(b)(3)

The defense program aimed at early destruction of an incoming missile carrying a nuclear warhead was now called Spartan. The Spartan missile was to be deployed on a trajectory that intercepted the enemy's incoming missile above the atmosphere

(b)(3)

[310] "W-Division Quarterly Status Report, October 1, 1967 through December 31, 1967, Part 2 of Two," W-2084 (SRD) (January 15, 1968), pp. 13–15, A86-016, 242-4.

(b)(3)

The Spartan and Sprint missiles together formed what was by this time period being called the Sentinel program. The Spartan was the device that was to be the initial high-altitude defense for destroying the incoming missile. The Sprint was to be the low-altitude backup device.

In January 1968, the responsibility for continued Phase 3 development of the Sprint warhead was transferred from Livermore to Los Alamos. This warhead was designated XW66. The primary responsibility for development of the Spartan warhead was assigned to Livermore. This warhead was designated XW71. However, the Los Alamos Laboratory was given a backup role for Spartan. The assignment memo from Assistant General Manager for Military Application Brig. Gen. Giller stated, "Los Alamos Scientific Laboratory/Sandia Corporation-Sandia Laboratory are to continue development of the SPITFIRE device as a backup warhead with warhead characteristics and schedules compatible with the SPARTAN program."[312]

(b)(3)

The latter two tests are included in the following paragraphs.]

(b)(3)

[312]Brigadier General Edward B. Giller, USAF, Assistant General Manager for Military Application, Headquarter, to Those listed below, Subject: "Laboratory Assignments for Development of Sentinel Warheads," (CRD) (January 22, 1968), 2 pp., A99-019, 1980-9. "LASL Program for Fiscal Years 1969-1970," DIR-2143 (SRD) (October 1, 1968), p. 12.

(b)(3)

(b)(3)

It was noted that very favorable results had been obtained from this experiment.[318]

(b)(3)

Advanced Spartan

An Advanced Spartan was also being considered in 1968. The third-quarter W-Division status report notes, "The first meeting of the Phase one AEC/DOD Advanced ABM Coordinating Group was held at AEC/DMA.

(b)(3)

[318]"W-Division Quarterly Status Report, April 1, 1968 through June 30, 1968, Part 2 of Two," W-2128 (SRD) (July 15, 1968), pp. 39–42, A86-016, 242-6.

(b)(3)

(b)(3)

Safeguard: Follow-On Sprint

The second quarter report from W-Division notes that a joint SLA/LASL document was being prepared that would summarize the Follow-On Sprint programs at the two Laboratories.[328] The W-Division quarterly report for July 1 through September 30, 1968, announced that a LASL/SLA program for the Follow-On Sprint was being studied. Design layouts were being prepared for two warhead proposals for the Upstage II interceptor that was a Follow-On Sprint variation.

(b)(3)

[328] "W-Division Quarterly Status Report, April 1, 1968 through June 30, 1968, Part 2 of Two," W-2128 (SRD) (July 15, 1968), p. 11, A86-016, 242-6.

(b)(3)

SCAD (Subsonic Cruise Armed Decoy)

(b)(3)

Meetings were being held in preparation for the Phase 2 meeting.[343] It was reported that drafts of the General Requirements for SCAD and the Phase 1 data package had been received from the Air Force Weapons Laboratory.[344]

MRV (Maneuvering Reentry Vehicle) and ARV (Advanced MRV)

The second quarter W-Division report notes, "Aerospace Corporation briefed the weapons laboratories on the status of the MRV program and requested preliminary warhead designs."[345]

A joint SLA/LASL data package was prepared for the Maneuvering Reentry Vehicle (MRV) program. (b)(3)

By the end of the year, the program had become the Advanced MRV (ARV). The working group for the ARV had been organized in a meeting on October 3, 1968; the first meeting of this working group had been held on December 2, 1968. (b)(3) However, despite this interest in the program, it was noted that ARV prototype development contracts were going to be delayed a year or more.[347]

MARS

There was also consideration of a system called MARS. This was a system to be mounted on armored vehicles. (b)(3)

BDM (Bomber Defense Missile) and DPM (Dual-Purpose Missile)

Also in this long "want" list from the Military was the Air Force interest in a Bomber Defense Missile (BDM) and a Dual-Purpose Missile (DPM). The Dual-Purpose Missile was to be a ramjet-propelled missile with a velocity of Mach 4 to 4.5 and a range of 300 miles.[349]

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343 "Program Status Weapons Research and Development, October-December 1968, Part 2 of Two," DIR-2156 (SRD) (no date), p. 9.

344 "W-Division Quarterly Status Report, October 1, 1968 through December 31, 1968, Part 2 of Two," W-2164 (SRD) (January 15, 1969), pp. 16–17, A86-016, 242-8.

345 "W-Division Quarterly Status Report, April 1, 1968 through June 30, 1968, Part 2 of Two," W-2128 (SRD) (July 15, 1968), p. 13, A86-016, 242-6.

(b)(3)

347 "W-Division Quarterly Status Report, October 1, 1968 through December 31, 1968, Part 2 of Two," W-2164 (SRD) (January 15, 1969), p. 12, A86-016, 242-8. "Program Status Weapons Research and Development, October-December 1968, Part 2 of Two," DIR-2156 (SRD) (no date), p. 8.

(b)(3)

349 "Program Status Weapons Research and Development, October-December 1968, Part 2 of Two," DIR-2156 (SRD) (no date), p. 8.

(b)(3)

/ Los Alamos supplied the Air Force Weapons Laboratory with a list of 20 possible warhead candidates for these applications.[350]

By the fourth quarter of 1968, meetings had been held with representatives of the Office of Research Analysis and AFWL.

(b)(3)

LAR (Low-Angle Reentry Vehicle)

The first quarter 1968 report from W-Division notes that a technical data package on a LAR (Low-Angle Reentry Vehicle) had been submitted to AFWL for submission to Air Force contractors.

(b)(3)

During the spring, meetings were held with DOD agencies and contractors to discuss the warhead proposals contained in the LASL Phase 1 data-package.[353]

(b)(3)

The final quarter report for the year from W-Division states, "A DoD contractor has completed the evaluation and pre-design study of the Low Angle Reentry Vehicle concept

(b)(3)

Primaries

(b)(3)

[350] "W-Division Quarterly Status Report, July 1, 1968 through September 30, 1968, Part 2 of Two," W-2145 (SRD) (October 15, 1968), p. 12, A86-016, 242-7.

(b)(3)

"W-Division Quarterly Status Report, April 1, 1968 through June 30, 1968, Part 2 of Two," W-2128 (SRD) (July 15, 1968), p. 11, A86-016, 242-6.

(b)(3)

ADM (Atomic Demolition Munition) and ADAM (Advanced Atomic Demolition Munition

~~There was~~ interest in an Atomic Demolition Munition (ADM) for the Army.

(b)(3)

~~The second quarter 1968 report~~ from W-Division notes that the second meeting concerning a possible ADM had been held on May 21–23.[359] LASL proposals were submitted in response to the requirements that had been outlined at the first meeting,

(b)(3)

'A nonnuclear self-destruct was to be included.)[360] The third quarter 1968 report from W-Division notes that the ADM proposals were being updated.[361]

During the latter part of 1968, the Army-approved requirements for an Advanced Atomic Demolition Munition (ADAM) were received at Los Alamos.[362]

(b)(3)

The final quarter 1968 report from W-Division states that a Phase 2-type data package was being prepared.[364]

Walleye

The first quarter report from W-Division states, "LASL is currently working with ALOO to re-do the Walleye Phase 2 cost data study prepared in January 1967. DMA is requesting detailed laboratory manpower and material cost estimates for these proposals and on all future Phase 2 studies."[365] [The reader will recall that the Walleye was an electro-optical guided glide bomb. It was designed for use by the Air Force's F-4D aircraft.]

It was felt that a Phase 3 development program for the Walleye might be authorized in FY 1969.[366] [The reader will recall that the Phase 3 was assigned in May 1969. The warhead would be given the nomenclature XW72.]

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359"W-Division Quarterly Status Report, April 1, 1968 through June 30, 1968, Part 2 of Two," W-2128 (SRD) (July 15, 1968), p. 10, A86-016, 242-6.

360"Program Status Weapons Research and Development, April-June 1968, Part 2 of Two," DIR-2133 (SRD) (no date), p. 7.

361"W-Division Quarterly Status Report, July 1, 1968 through September 30, 1968, Part 2 of Two," W-2145 (SRD) (October 15, 1968), p. 11, A86-016, 242-7.

362"Program Status Weapons Research and Development, October-December 1968, Part 2 of Two," DIR-2156 (SRD) (no date), p. 8.

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364"W-Division Quarterly Status Report, October 1, 1968 through December 31, 1968, Part 2 of Two," W-2164 (SRD) (January 15, 1969), p. 11, A86-016, 242-8.

365"W-Division Quarterly Status Report, January 1, 1968 through March 31, 1968, Part 2 of Two," W-2104 (SRD) (April 15, 1968), p. 8, A86-016, 242-5.

366"LASL Program for Fiscal Years 1969-1970," DIR-2143 (SRD) (October 1, 1968), p. 14.

Sparrow

There were also discussions with the Air Force Weapons Laboratory on providing a warhead for what was called an Advanced Sparrow missile.[367]

d. Projectiles and Earth-Penetrating Weapons

Bayonet

The program called Bayonet continued in 1968. The concept at this time was for this device to include a shaped charge of HE that was designed to detonate when the missile was a few feet from the ground. The ensuing jet was supposed to penetrate the earth, and in theory, enable an easier entry for the nose of the missile. The problem with the concept was how to penetrate hard rock.[368]

The second quarter W-Division report indicates that further work and redesign of the system had taken place in the reporting period of April 1–June 30, 1968. The report notes, "Except for the additional tests of the redesigned internal ballistic system, the planned Bayonet feasibility program has been completed."[369]

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[367]"Program Status Weapons Research and Development, April-June 1968, Part 2 of Two," DIR-2133 (SRD) (no date), p. 8. "W-Division Quarterly Status Report, July 1, 1968 through September 30, 1968, Part 2 of Two," W-2145 (SRD) (October 15, 1968), p. 11, A86-016, 242-7.

[368]"Program Status Weapons Research and Development, July-September 1968, Part 2 of Two," DIR-2142 (SRD) (no date), p. 9.

[369]"W-Division Quarterly Status Report, April 1, 1968 through June 30, 1968, Part 2 of Two," W-2128 (SRD) (July 15, 1968), pp. 14–15, A86-016, 242-6.

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155-mm

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8-inch

An in-house meeting was held in Albuquerque in November for the purpose of considering a new 8-inch artillery-fired atomic projectile (AFAP). The Phase 2 meeting was held in December. It was reported that it had been concluded that a new nuclear warhead was feasible.[375]

e. Nonnuclear Kill

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375 "Program Status Weapons Research and Development, October-December 1968, ~~Part~~ 2 of Two," DIR-2156 (SRD) (no date), p. 9. "W-Division Quarterly Status Report, October 1, 1968 through December 31, 1968, Part 2 of Two," W-2164 (SRD) (January 15, 1969), p. 16, A86-016, 242-8.

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Steel Rods

There was also interest by the Air Force in a technique of nonnuclear kill of reentry vehicles using high-velocity (4,000–6,000 m/s) 50-g steel rods. These would be accelerated using a nuclear detonation. It was hoped that retired W59 warheads could be modified for use in the program.[377]

The year-end quarterly report from the Laboratory notes that two W59 warheads were being modified for tests.[378] The year-end quarterly report from W-Division states, "The extent of LASL participation in this program is to review the test and packaging procedures for nuclear safety hazards and post-test assessment of warhead damage."[379]

5. 1969

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Backup Spartan

In a letter dated January 28, 1969, from the AEC, the Laboratory was informed, "This office has been informally advised by DMA that the LASL Spartan backup device has been deleted from the STS program." The letter added, "Accordingly, it is requested that you examine your STS support requirements in order to gain an early appreciation of those items that might be affected by this change."[380]

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377"Program Status Weapons Research and Development, April-June 1968, Part 2 of Two," DIR-2133 (SRD) (no date), p. 8. "W-Division Quarterly Status Report, July 1, 1968 through September 30, 1968, Part 2 of Two," W-2145 (SRD) (October 15, 1968), p. 12, A86-016, 242-7.

378"Program Status Weapons Research and Development, October-December 1968, Part 2 of Two," DIR-2156 (SRD) (no date), p. 8.

379"W-Division Quarterly Status Report, October 1, 1968 through December 31, 1968, Part 2 of Two," W-2164 (SRD) (January 15, 1969), pp. 11–12, A86-016, 242-8.

380Robert E. Miller to W. D. Smith, Jr. et. al., Subject: "STS Program Adjustment," (CRD) (January 28, 1969), 1 p., A99-019, 218-4.

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Improved Spartan

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The LASL warhead proposals for an Improved Spartan program were outlined in detail in an April 21, 1969, paper.[385]

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However, the W-Division report for April–June notes that it appeared that the Phase 2 study was going to be delayed.[386]

The Laboratory's quarterly report of July–September 1969 indicates that while the final Phase 3 Spartan missile warhead development for the Safeguard program had gone to Livermore as the W71, the Los Alamos teams were continuing to work on the development of an Improved Spartan—a follow-on program to the Spartan.

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It was expected that the Phase 1 data package for the Improved Spartan would be forwarded to the DDR&E (Director, Defense Research and Engineering) around October 1.[387] The W-Division report for July–September 1969 indicates that in July the Safeguard System Command had published a

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[385]"LASL Warhead Proposals for Improved Spartan Program," W-9-390 (SRD) (April 21, 1969), 5 pp., A99-019, 218-4.

[386]"W-Division Quarterly Status Report, April 1, 1969 through June 30, 1969, Part 2 of Two," W-2199 (SRD) (July 15, 1969), p. 21, A86-016, 242-10. "Program Status Weapons Research and Development, April – June 1969, Part 2 of Two (U)," DIR-2180 (SRD) (no date), p. 11.

[387]"Program Status Weapons Research and Development, July - September 1969 (U)," DIR-2187 (SRD) (no date), pp. 46–47, 61.

schedule for the development of a warhead section for the Improved Spartan. The Phase 1 report was to be completed by September 1969 and the Phase 2 by January 1970. However, it appeared that this schedule was slipping.[388]

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Additional information is available in the cited reference.[391]

SABMIS (Sea-Based Ballistic Missile Intercept System)

A January 9,1969, TWX from the Assistant General Manager for Military Application, Edward B. Giller, reported that the DOD was studying the SABMIS concept in order to add depth to the defenses of the continental U.S. In addition, SABMIS had the advantage that it would be a mobile system that would be available for the defense of an overseas area; nuclear weapons would not have to be deployed ashore.

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[388] "W-Division Quarterly Status Report, July 1, 1969 through September 30, 1969," W-2217 (SRD) (October 15, 1969), p. 14, A86-016, 242-11.

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[391] "W-Division Quarterly Status Report, April 1, 1969 through June 30, 1969," W-2198 (SRD) (July 15, 1969), pp. 50–58, A86-016, 242-10.

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The final W-Division quarterly report for 1969 states that the Phase 1 data-package for the Mk 19 had been reviewed on October 16, 1969, during a meeting at the Air Force Weapons Laboratory. It appeared that the program would go to Phase 2. The Air Force Scientific Advisory Board had received a review of the LASL program,

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[Author's note: The Mk 19 program would be the precursor to the XW78.]

New Full Fusing Option (FUFO) Bomb

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In a Phase 1 study, the weapon laboratories had outlined the possibilities for this type of bomb in terms of yield, size, and weight.[401]

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LORAH (Long Range Area Homer)

During the first quarter of 1969, it was reported that preliminary studies had been conducted by the Advanced Ballistic Missile Defense Agency and its contractors on future missile defense systems. A system-concept known as Long-Range Area Homer (LORAH) had been selected for more detailed study.[403]

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[401] "W-Division Quarterly Status Report, October 1, 1969 through December 31, 1969," W-2235 (SRD) (January 15, 1970), p. 42, A86-016, 242-12.

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[403] "Program Status Weapons Research and Development, January – March 1969, Part 2 of Two (U)," DIR-2172 (SRD) (no date), p. 12. "W-Division Quarterly Status Report, January 1, 1969 through March 31, 1969, Part 2 of Two," W-2193 (SRD) (April 15, 1969), p. 22, A86-016, 242-9.

During the second quarter, Los Alamos personnel supplied basic warhead data to attendees at a joint AEC/DOD meeting.[404] The second quarter 1969 W-Division report states for the LORAH system, "Initial design parameters of the proposed missile delivery system indicate that a small nuclear yield will meet the target kill requirements if the small miss distance (≈30–50 ft versus the 50–100 ft previously stated as a design goal) can be provided by the guidance/homer system now under study for the LORAH system."[405]

The fourth quarter W-Division report for 1969 notes that in a three-day meeting held during the first part of November, the studies on LORAH, completed by three different contractors, had been presented to the Advanced Ballistic Missile Defense Agency. The results of the three studies had been almost identical. The interceptor would carry 4 to 6 vehicles to an intercept point after which an interceptor-borne sensor would identify targets. As targets were identified, a homing sensor would lock on and would "zero in on the target." The high accuracy of hitting the target would permit the use of very low-yield warheads. It was noted, "The LORAH concept is under study for the 1980s to operate in conjunction with the SAFEGUARD defense system."[406]

Bomber Defense Missile, Dual-Purpose Missile

During January–March 1969, discussions were continued with personnel from the Air Force Weapons Laboratory and their contractors on warhead proposals for the Bomber Defense Missile (BDM) and the Dual Purpose Missile (DPM). It was noted that yields of 1- to 10-kt were of interest for the BDM; yields of 5- to 200-kt were of interest for the DPM.[407]

During the second quarter of 1969, a joint LASL/SLA information document (as input for a study of possible warheads for the DPM) was submitted to the AFWL.

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The Laboratory status report for July–September 1969 notes that the final report on the DPM had been completed by the Office of Research Analysis of the U.S. Air Force. The W-Division quarterly report notes, "LASL has received volumes 1, 2, 3, 4, 6 and 9 of this extensive report. This report recommends further investigation on air-breathing propulsion, missile guidance, and low radar cross sections."

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[404] "Program Status Weapons Research and Development, April – June 1969, Part 2 of Two (U)," DIR-2180 (SRD) (no date), p. 10.

[405] "W-Division Quarterly Status Report, April 1, 1969 through June 30, 1969, Part 2 of Two," W-2199 (SRD) (July 15, 1969), p. 19, A86-016, 242-10.

[406] "W-Division Quarterly Status Report, October 1, 1969 through December 31, 1969," W-2235 (SRD) (January 15, 1970), p. 37, A86-016, 242-12.

[407] "Program Status Weapons Research and Development, January – March 1969, Part 2 of Two (U)," DIR- 2172 (SRD) (no date), p. 11. "W-Division Quarterly Status Report, January 1, 1969 through March 31, 1969, Part 2 of Two," W-2193 (SRD) (April 15, 1969), p. 19, A86-016, 242-9.

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The fourth quarter 1969 report from W-Division states that the Air Force had approved a funded design study for a Short Range Bomber Defense Missile. The Los Alamos weapon groups in support of this study had sent warhead information to the Air Force Weapons Laboratory.[410]

SCAD (Subsonic Cruise Attack Decoy)

Early in 1969, preparations continued for an anticipated AEC/DOD Phase 2 meeting on the Subsonic Cruise Attack Decoy (SCAD).

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~~The July~~-September ~~quarterly~~ reports prepared by the Laboratory groups announced that three contractors were making further feasibility studies, to be completed by September 30, 1969, on the SCAD proposal.

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It was stated, "Studies have been made to determine whether a particular combination will give a significant range advantage to the SCAD.

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ARV (Advanced MRV)

It was announced that the Air Force had awarded identical ARV contracts effective May 1, 1969 to two contractors. These were for the purpose of evaluating flight control system concepts for Terminal Evasion/Accuracy and for Terminal-Evasion-only MRVs. [The ARV program had been extended to include studies of a Simple Terminal Evasion (STE) vehicle as well as the Terminal Evasion/Accuracy vehicle.]

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[410] "W-Division Quarterly Status Report, October 1, 1969 through December 31, 1969," W-2235 (SRD) (January 15, 1970), p. 40, A86-016, 242-12.

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The third quarter report from Los Alamos notes that in the planning considerations, the Panther A primary had been used in the baseline design for the Terminal Evasion/Accuracy MRV. Two technical exchange meetings had been held in August.[415]

The final quarter report for 1969 from W-Division indicates that, in support of the ARV program, personnel from LASL had attended the Technical Direction meetings with the Air Force and their two contractors. The present ARV study program, with the primary goal of evaluating flight control systems, was scheduled for completion in February 1970.[416]

ASMA (Advanced Surface Missile)

During the second quarter of 1969, it was reported that an Advanced Surface Missile System (ASMA) was under consideration. (b)(3) The nuclear warhead section was to be interchangeable with the HE warhead.[417]

Terminal Homing Vehicle

During the second quarter of 1969, it was also announced that the Air Force had started a program to evaluate the possibility of using the Minuteman in an offensive/defensive role. In the Terminal Homing Vehicle concept, the payload of the Minuteman would become a homing vehicle able to "home in on an incoming reentry vehicle." The vehicle would incorporate either a nonnuclear or nuclear kill warhead. The status reports from the Laboratory indicate that a joint LASL/SLA nuclear warhead data package had been prepared.[418]

LAR (Low-Angle Entry Vehicle)

In terms of the Low-Angle Entry Vehicle (LAR) it was reported in the W-Division third quarter report that an 18-month contract had been awarded for the conduct of the Feasibility Flight Test Program.[419] The July–September status report from the Laboratory notes, "...we do not expect to have discussions concerning the warhead until the end of the program; that is when the actual flight tests have been conducted."[420]

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415 "*Program Status Weapons Research and Development, July - September 1969 (U)*," *DIR-2187 (SRD)* (no date), pp. 9–10.

416 "W-Division Quarterly Status Report, October 1, 1969 through December 31, 1969," W-2235 (SRD) (January 15, 1970), p. 39, A86-016, 242-12.

417 "Program Status Weapons Research and Development, April – June 1969, Part 2 of Two (U)," DIR-2180 (SRD) (no date), p. 11. "W-Division Quarterly Status Report, April 1, 1969 through June 30, 1969, Part 2 of Two," W-2199 (SRD) (July 15, 1969), p. 20, A86-016, 242-10.

418 "Program Status Weapons Research and Development, April – June 1969, Part 2 of Two (U)," DIR-2180 (SRD) (no date), p. 11. "W-Division Quarterly Status Report, April 1, 1969 through June 30, 1969, Part 2 of Two," W-2199 (SRD) (July 15, 1969), p. 21, A86-016, 242-10.

419 "W-Division Quarterly Status Report, July 1, 1969 through September 30, 1969," W-2217 (SRD) (October 15, 1969), p. 15, A86-016, 242-11.

420 "Program Status Weapons Research and Development, July - September 1969 (U)," DIR-2187 (SRD) (no date), p. 10.

SAM-D (Surface-to-Air Missile-D)

The Army planned to replace the Nike Hercules and Hawk with a Surface-to-Air Missile-D (SAM-D).

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Air Interceptor Missile (AIM)

The final quarter 1969 report from W-Division notes that the Navy had submitted a request for an AEC Phase 2 feasibility study on possible warhead candidates for the Phoenix missile.[422] [Additional information on Phoenix is given in the 1970 section.]

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High-Yield Source

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ADAM (Advanced Atomic Demolition Munition)

During the first quarter of 1969, the Laboratory's Phase 2 input for the Advanced Atomic Demolition Munition (ADAM) study was coordinated within the Laboratory. This study was to be submitted early in April.[425]

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[422] "W-Division Quarterly Status Report, October 1, 1969 through December 31, 1969," W-2235 (SRD) (January 15, 1970), p. 38, A86-016, 242-12.

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[425] "Program Status Weapons Research and Development, January – March 1969, Part 2 of Two (U)," DIR-2172 (SRD) (no date), p. 10. "W-Division Quarterly Status Report, January 1, 1969 through March 31, 1969, Part 2 of Two," W-2193 (SRD) (April 15, 1969), p. 17, A86-016, 242-9.

The Laboratory quarterly report for July–September 1969 notes that the ADAM Phase 2 feasibility study had been published by the Army. The AEC Impact and Capabilities study had been published by the Albuquerque Operations Office (ALO).[426]

Advanced Sparrow

During the first quarter of 1969, there continued to be interest in what was called the Advanced Sparrow missile. The warhead was to weigh about 90 lb and have an 8-inch diameter and a length of 17.5 inches (b)(3) The warhead was to be a direct replacement of the conventional HE warhead.

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The first quarter report from W-Division notes that a joint LASL/SLA input had been submitted to AFWL for a Phase 1 feasibility study for a nuclear capability for the Advanced Sparrow missile.[428]

Walleye Phase 3

The Phase 3 for the Walleye missile warhead (BA72) was awarded in May 1969. It was noted that development would be mainly a Sandia activity.[429]

New Implosion System

(b)(3)

d. Projectiles and Earth-Penetrating Devices

Eight-Inch Artillery-Fired Atomic Projectile (AFAP)

During the first quarter of 1969, it was reported that the Phase 2 feasibility study and the additional Impact and Capability report for a new 8-inch nuclear artillery round was nearing completion. (b)(3)

426 "Program Status Weapons Research and Development, July - September 1969 (U)," DIR-2187 (SRD) (no date), p. 48.

(b)(3)

428 "W-Division Quarterly Status Report, January 1, 1969 through March 31, 1969, Part 2 of Two," W-2193 (SRD) (April 15, 1969), p. 17, A86-016, 242-9.

429 "Program Status Weapons Research and Development, April – June 1969, Part 2 of Two (U)," DIR-2180 (SRD) (no date), p. 16.

(b)(3)

The Phase 2 study for the 8-inch AFAP was completed during the second quarter and the applicable reports were issued.[433]

155-mm

During the first quarter of 1969, the Phase 2 feasibility study for a new 155-mm nuclear round for the Army was reported to be nearing completion. The Los Alamos design group had proposed two designs.

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The April–June quarterly report announced that the Phase 2, 155-mm study had been completed; the Phase 2 meeting had been held in February 1969. The Phase 2 report was dated May 2, 1969; the Impact and Capabilities Study was dated April 18, 1969.[435]

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Engineering studies, gun-firing tests, and materials-development activities were in progress or planned.[438]

Bayonet

The first part of 1969 saw completion of the engineering tests for the Bayonet feasibility program.[439]

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[433] "Program Status Weapons Research and Development, April – June 1969, Part 2 of Two (U)," DIR-2180 (SRD) (no date), p. 11. "W-Division Quarterly Status Report, April 1, 1969 through June 30, 1969, Part 2 of Two," W-2199 (SRD) (July 15, 1969), p. 19, A86-016, 242-10.

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[435] "Program Status Weapons Research and Development, April – June 1969, Part 2 of Two (U)," DIR-2180 (SRD) (no date), pp. 10–11. "W-Division Quarterly Status Report, April 1, 1969 through June 30, 1969, Part 2 of Two," W-2199 (SRD) (July 15, 1969), p. 19, A86-016, 242-10.

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[438] "Program Status Weapons Research and Development, October-December 1969 (U)," DIR-2195 (SRD) (no date), pp. 65–66.

[439] "Program Status Weapons Research and Development, January – March 1969, Part 2 of Two (U)," DIR-2172 (SRD) (no date), p. 12. "W-Division Quarterly Status Report, January 1, 1969 through March 31, 1969, Part 2 of Two," W-2193 (SRD) (April 15, 1969), p. 24, A86-016, 242-9.

e. Nonnuclear Kill

For the program involving the acceleration of steel as a kill mechanism, the Laboratory's 1969 first-quarter report states that the W59 warheads had been modified and were ready for delivery to the test facility.[440]

A meeting had been held to review and coordinate various phases of the hypervelocity-projectile tests on two modified W59 warheads in Mark-5 reentry vehicles. Two test shots were initially planned. One would use a 50-gram steel rod moving at 20,000 ft/s into the midsection of the W59. The other would use a 50-gram steel rod moving at 20,000 ft/s into the secondary of the W59.[441]

6. 1970

(b)(3)

CAFE (C-3 Alternate Front End)

In a TWX dated May 11, 1970, it was noted that there might be a ban on the use of MIRV (Multiple Independent Reentry Vehicle) type deployment. DOD personnel were therefore reviewing capabilities for alternate strategic missile loadings. In particular, the Navy was concerned about a design that could be used as a single RB on Poseidon.[442]

The W-Division third quarter (July 1, 1970, through September 30, 1970) report announced that a design study for CAFE had been prepared. The CAFE (C-3 Alternate Front End) study was to identify the preferred design for a new reentry body payload for the Poseidon C3 missile. It was reported that two possible modifications to the W67 warhead had been included in this study.

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The first CAFE Reentry Interchange Committee Meeting took place on July 15, 1970. An informal meeting was held between LASL/SLA and LMSC (Lockheed Missiles and Space Company) on July 22, 1970. In a submittal to C. E. Grant (through the Navy Plant Representative) at Lockheed Missiles and Space Company dated August 7, 1970, the Los Alamos and Sandia Albuquerque laboratories submitted a paper titled, "LASL/SLA Warhead Data for CAFE Study."

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Another meeting on the CAFE program took place on September 18, 1970. During this meeting, a follow-on phase of the CAFE study was requested

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[440] "Program Status Weapons Research and Development, January – March 1969, Part 2 of Two (U)," DIR-2172 (SRD) (no date), p. 10.

[441] "W-Division Quarterly Status Report, January 1, 1969 through March 31, 1969, Part 2 of Two," W-2193 (SRD) (April 15, 1969), p. 18, A86-016, 242-9.

[442] USAEC, Thomas R. Clark, Wash., D.C. to AN1, USAEC, H. C. Donnelly, Albuq., N.M. et. al. (SRD) (May 11, 1970), 6 pp., A99-019, 188-4.

(b)(3)

The fourth quarter report from W-Division for 1970 notes that the Poseidon C3 Alternate Front End Study had been completed by Lockheed Missiles and Space Company. The purpose of the study had been to identify the preferred design for a new reentry body payload, called the *Mk 1 Prime, for the Poseidon missile in the event that the Mk 3 MIRV system could not be* deployed as planned.

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The total warhead weight was 680 lb.[446]

Improved Spartan

(b)(3)

Phase 6 for the W71 would not be achieved until October 1974. (The weapon would be placed in the inactive stockpile in October 1976.[447])

In a February 24, 1970, letter to Chairman of the AEC, Glenn T. Seaborg, John S. Foster, Director of Defense Research and Engineering wrote, "The Department of Defense desires to determine the feasibility of a nuclear warhead for the Improved SPARTAN missile warhead section....The Improved SPARTAN missile is a sub-system of the SAFEGUARD ballistic missile defense system and is being designed to provide a long-range intercept capability in the exoatmosphere against ICBM and SLBM reentry vehicles (RVs), long-range intercept capability in the atmosphere against depressed trajectory RVs, a capability to intercept penetration-aided RVs, an endo- and exoatmospheric intercept capability against FOBS [Fractional Orbital Bombardment System], and an intercept capability against satellites (but only within missile performance limitations)." [Author's note: Wow, what an assignment!] Foster noted that the presently planned improved Spartan missile would use the Spartan missile's first and second stages while incorporating a new third stage

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An effort through Phase 2 was requested for this improved Spartan missile.[448]

(b)(3)

The Laboratory's quarterly report for January–March 1970 states, "Though there are many system parameters as yet unresolved, the AEC has received a formal request to participate in the Phase 2 Feasibility study of warhead designs for the Modified Spartan missile system."

(b)(3)

[446]"Program Status Weapons Research and Development, October-December 1970 (U)," Los Alamos Scientific Laboratory report LA-4614-MS (SRD) (February 1971), p. 42. "W-Division Quarterly Status Report, October 1, 1970 through December 31, 1970," W-2301 (SRD) (January 15, 1971), p. 66, A86-016, 242-15.

[447]"FY 1994 Annual Weapons Program Report," DOE Operation Office report (SRD) (October 1, 1994), pp. 318–322.

[448]John S. Foster, Jr. to Honorable Glenn T. Seaborg (SRD) (February 24, 1970), 5 pp., A99-019, 186-10.

(b)(3)

The document noted that the improved Spartan would incorporate a larger and more powerful third stage motor. This new motor would allow for greater missile maneuverability and therefore allow a reduction in warhead miss distance. It would also allow for a "loiter" capability. The warhead would need to be multipurpose.

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It was also noted that if the Safeguard system were extended to maximum deployment, it could be extended to include an area defense of the population against a light or

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irrational attack, or against accidental launches.

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Mk 19

(b)(3)

A TWX dated September 15, 1970, pointed out that the system cost for the Minuteman III and MIRV was 2.2 billion. The projected cost for the Mk 19 was approximately 130 million. Thus, the R&D cost for the Mk 19 was 5% of the total system costs.[467]

(b)(3)

FUFO

During 1970, the DOD guidance placed emphasis upon a new FUFO bomb

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SABMIS

There also continued to be an interest in a Sea-Based Anti-Ballistic Missile Intercept System. It was reported that development schedules for this system were such that tests of the warheads themselves would not be scheduled for FY 1971.

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[467]D. W. Bergen, Los Alamos Scientific Laboratory, Los Alamos, N.M. to C. I. Hudson, University of California, Lawrence Radiation Laboratory (SRD) (September 15, 1970), p. 3, A99-019, 188-4.

(b)(3)

ACE (Advanced Control Experiment)

Another program under consideration in 1970 was called ACE. These letters stood for Advanced Control Experiment. The purpose of the program was to develop and flight test a maneuvering reentry vehicle. It was noted that McDonnell-Douglas and General Electric were working for SAMSO (Space and Missile Systems Organization) on a predesign study to last through November 1970. The mission of the ACE warhead was "assured destruction." At that time, the concept was to use three, 350-lb RVs per Minuteman booster.

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Representatives from Los Alamos had attended design meetings at McDonnell-Douglas, Huntington Beach, California, and at General Electric, Philadelphia, Pennsylvania. Additional information is available in the cited reference.[477]

ABC (Advanced Ballistic Concept)

The October–December quarterly report from the Laboratory indicates a program called the ABC (Advanced Ballistic Concept).

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In 1970, a joint operation agreement was reached between Los Alamos and SAMSO on the ABC program. From the starting date of June 29, 1970, the program was to have a 26-month study period. The Air Force Systems Command and SAMSO were responsible for program management. The Aerospace Corporation was responsible for the general systems engineering and technical integration. The AEC contractor was the AVCO Corporation.[479]

LAR (Low-Angle Reentry Vehicle)

The Low-Angle Reentry vehicle (LAR) was also during 1970 being considered for development. (b)(3)

LORAH (Long Range Area Homer)

In 1970 the Long Range Area Homer system was also being proposed for use with a nuclear warhead. It was felt that tests of the LORAH warhead would have to include diagnostic measurements of the fast neutron and high-energy x-ray output from the small, lightweight warhead. However, it was reported that development was not far enough along that tests needed to be included in the schedule for FY 1971.[481]

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[477] J. J. Jacoby, W-4 to R. G. Shreffler, Subject: "ACE Trip Report – First Design Review," W-4-2980 (SRD) (August 26, 1970), 6 pp., A99-019, 307-4.

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[479] "Joint Operating Agreement Between Los Alamos Scientific Laboratory and SAMSO on the ABC Program," (U) (no date), p. 1, Table I, film GAMF-1208, Los Alamos Records Center.

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[481] Charles I. Browne to Mr. W. R. Cooper, JOT-104-70 (SRD) (May 15, 1970), p. 4, A99-019.

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Earth Penetrators

The final quarter W-Division report for 1970 indicates that there was an earth-penetrating program called Rumpler. LASL had received authorization in November to participate with Picatinny Arsenal and SLA in a joint program to explore the feasibility of the Rumpler concept. LASL was to be responsible for the study of the nuclear device for inclusion in the penetrator. The final quarterly report for 1970 from the Laboratory states, "The Rumpler program is an attempt to demonstrate the feasibility of penetrating earth to a moderate depth with a missile launched straight down from a mobile recoilless rifle on a portable field mount

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7. 1971

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Modified Spartan

The Laboratory status report for the first quarter of 1971 noted that the Laboratory was continuing work on a Modified Spartan program.

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It was noted that the Scimitar proposal had been released for inclusion in the AEC advanced planning document and also for the Phase 2 feasibility document.[489] The W-Division report for the first quarter also notes that detailed studies had been applied to the Scimitar proposal for the Modified Spartan.[490]

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[489] "Quarterly Status Report on Weapons Research and Development for the Period Ending March 31, 1971 (U)," Los Alamos Scientific Laboratory report LA-4680-MS (SRD) (May 1971), p. 30.

[490] "W-Division Quarterly Status Report, January 1, 1971 through March 31, 1971," W-2318 (SRD) (April 15, 1971), p. 14, A86-016, 242-16.

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It is a step in the development of a warhead for the Modified SPARTAN."[493]

Hardsite Defense (SPRINT II)

The third quarter report for 1971 from the Laboratory notes that a new component of the Safeguard ABM system, called "Hardsite Defense" (HSD), was to be implemented. It was reported, "HSD consists of an autonomous module for close-in, low-altitude intercept (≈10,000 to 30,000 ft) and is based upon three radar/data-processor units located about 10 nautical miles apart. The module will have six or seven firing sites containing about 100 modified Sprint interceptors to defend approximately 21 silos." The new interceptor was to be known as Sprint II: the planned readiness date was July 1977.

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An AEC/DOD Joint Working Group had been set up to provide an alternative that used less tritium. A number of proposals had been suggested,

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[493] D. P. MacDougall to Major General E. B. Giller, USAF, ADW-158 (SRD) (November 5, 1971), p. 4, A99-019, 258-28.

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By the fourth quarter of 1971, requirements for the High-Yield Bomb had become more specific.

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The bomb was to be delivered by both tactical and strategic aircraft. Five candidates for the Phase 2 had been selected and the joint SLA-LASL input for the Phase 2 study had been submitted to FC/DNA on December 20.[504]

<u>High-Yield Multiple RV (Mk 19)</u>

The high-yield multiple RV program was also <u>underway in</u> 1971. This program was in reality a continuation of the Mk 19 effort.

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[504]"Quarterly Status Report on Weapons Research and Development for the Period Ending December 31, 1971 (U)," Los Alamos Scientific Laboratory report <u>LA-4880-PR (SRD) (March 1972)</u>, p. 36.

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High-Yield Warheads

Harold Agnew in a letter to Assistant General Manager for Military Application, Major General Edward B. Giller, stated that the country should consider what would happen if there were to be a ban on the use of MIRV and at the same time there was a ban on testing. Agnew recommended that the country should develop and test the highest possible yield warhead that could be carried as a single [warhead] on the Poseidon. He felt that the same should be done for the Minuteman and, if the Titan were kept in service, a high-yield warhead should also be developed for this application./He noted, "...we won't be carrying out our responsibility to the U.S. if we don't do these nuclear developments."[510]

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[510]H. M. Agnew to Major General Edward B. Giller, DIR-2250 (SRD) (July 6, 1971), 2 pp., A99-019, 269-3.

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VSM (Very Small Multiple)

Also mentioned in this time period was the Very Small Multiple (VSM) concept where 10 to 14 warheads would be carried on the Minuteman III missile,

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c. Single Stage

ADM (Atomic Demolition Munition) and SADM (Small Atomic Demolition Munition)

The first quarter report from the Laboratory states, "A study has been made to determine the amount of stemming necessary for significant containment of a NATO ADM device detonated in a simple hole relatively near the surface (45 ft).",

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The energy moving up the hole was deposited in the walls generating a radial shock that enlarged the hole.[519]

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High-Yield Primary

There were several tests related to the development of a high-yield primary.

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[519] "Quarterly Status Report on Weapons Research and Development for the Period Ending March 31, 1971 (U)," Los Alamos Scientific Laboratory report LA-4680-MS (SRD) (May 1971), pp. 33–34.

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8. 1972 and First Quarter of 1973

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Modified Spartan

In a February 28, 1972, memo, D. P. MacDougall reported that the AEC's Giller anticipated that a Phase 3 request might be initiated in the FY 1972–1974 time period for the Modified Spartan.[531]

The Phase 2 report for the modified Spartan was published in April 1972

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Site Defense (Sprint II)

The Laboratory's first quarter report for 1972 indicates that the Laboratory weapon groups were continuing to work on the Hardsite Defense program. However, the program was now called Site Defense. Its objective was to defend a portion of the U.S. Minuteman force. The new interceptor for this program, called Sprint II, had a slightly reduced launch dispersion, increased hardness, and decreased miss distance. The missile in its cell, as well as the entire module, was to operate virtually unattended. The planned readiness date continued to be July 1977.[533]

In a February 28, 1972, memo, D. P. MacDougall reported that in a January 20, 1972, document, Giller had indicated the he anticipated that a Phase 3 request might be initiated in the FY 1972–1974 time period for a Hardsite Defense System (Sprint II).[534]

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[531]D. P. MacDougall to Distribution, Subject: "Program Planning," ADW-204 (SRD) (February 28, 1972), 3 pp., B11. Drawer 49. Folder 1 of 5.

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[533]Leslie M. Redman and Cecil C. Carnes, "Quarterly Status Report on Weapons Research and Development for the Period Ending March 31, 1972 (U)," Los Alamos Scientific Laboratory report LA-4965-PR (SRD) (June 1972), p. 54.

[534]D. P. MacDougall to Distribution, Subject: "Program Planning," ADW-204 (SRD) (February 28, 1972), 3 pp., B11. Drawer 49. Folder 1 of 5.

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High-Yield Bomb (HYB), Formerly FUFO

In a February 28, 1972, memo, D. P. MacDougall reported that Giller in a January 20, 1972, document had indicated that he anticipated that a Phase 3 request might be initiated in the FY 1972–1974 time period for a High-Yield Bomb (HYB) (formerly FUFO).[543]

The second quarter report from the Laboratory for 1972 includes, as part of the High-Yield Bomb program, what was to become a very important project for the Laboratory. The report states, "The explosive TATB (1,3,5-triamino-2,4,6-trinitrobenzene) was first described in 1888, but was recognized as a very interesting heat-resistant explosive only in the 1950s. At that time the Naval Ordnance Laboratory reported briefly on its properties and presented a reasonable synthesis." The report notes that this material had a great insensitivity to impact and friction and an explosive power superior to that of other heat-resistant explosives,

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The third quarter report for 1972 states, "We have continued experiments to characterize the 90/10 TATB-Kel-F 800 material discussed last quarter, hampered somewhat by our limited stock of material. First deliveries of TATB from Pantex are expected soon to alleviate this shortage."[545]

The third quarter report also states, "The USAF and USN have studied the 'Final Report of the Phase 2 Feasibility Study of the High Yield Bomb,' dated March 21, 1972, ...and agree that it is technically feasible to develop a high-yield bomb that meets the stated requirements, with a minimum 4-yr development time, and that no bombs that meet the requirements of the HYB are currently available or in production. Subsequently, the Services have requested a Phase 3 Development Engineering program for the HYB.

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[543]D. P. MacDougall to Distribution, Subject: "Program Planning," ADW-204 (SRD) (February 28, 1972), 3 pp., B11. Drawer 49. Folder 1 of 5.

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[545]Leslie M. Redman and Cecil C. Carnes, Jr., "Quarterly Status Report on Weapons Research and Development for the Period Ending September 30, 1972 (U)," Los Alamos Scientific Laboratory report LA-5130-PR (SRD) (January 1973), pp. 53–54.

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The Laboratory's fourth quarter report for 1972 announced that a new full-fuzing-option (FUFO) bomb program had been requested. (This program took the place of the high-yield bomb program.) The bomb size was limited to a maximum of 18-in. diameter, 145-in. length, and a 2,400-lb weight. It was to have full-fuzing options and improved safety characteristics. It would be for delivery by both strategic and tactical aircraft.

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This new FUFO bomb program was a result of the review of the March 21, 1972, Phase 2 Feasibility Study of the High-Yield Bomb and the decision that certain aspects of the feasibility study should be expanded before a final decision was made on a Phase 3 development. In terms of design considerations, for the LASL proposals it was noted that, for safety reasons, it was desirable that the bomb incorporate use of the new insensitive explosive

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High-Yield, Multiple RV (Mk 19, Modified Mk 12)

The high-yield, multiple RV program was continued in 1972

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On August 17, 1972, the Air Force Weapons Laboratory requested a new Phase I study to support renewed Air Force interest in a new ballistic RV for the MM (Minuteman) III. Two types of RVs were to be considered in the Phase I study. One type was to be a modified Mk 12 RV with a maximized

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yield consistent with the Mk 12 envelope. (b)(3)

Responding to this request, the LASL designers developed a design that they felt was suitable for incorporation into the modified Mk 12.

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A letter dated October 4, 1972, transmitted the formal LASL/SLA Phase-I warhead concept information for the new Minuteman III ballistic reentry vehicle program. (b)(3)
(b)(3) It was noted, "Our [LASL] studies on the Mk 19 reentry systems for Minuteman began in early 1969. Since then we have had continuing efforts on both RV synthesis and warhead design and testing." Additional information is available in the cited reference.[558]

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A new Planning Information Document to reflect this thinking had been issued by the Albuquerque Office (ALO).

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[558]C. M. Gillespie and T. A. Sandford to Col. Charles C. Hyre, Air Force Weapons Laboratory, Kirtland Air Force Base, N.M. 87117, ADWP-72-45 (SRD) (October 4, 1972), 16 pp., B11, Drawer 53, Folder 2 of 2.

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PAR (Prototype Advanced Reentry)

It was also announced in the third quarter 1972 report from the Laboratory that the Aerospace Corporation was considering a possible study for a high-yield prototype advanced reentry (PAR) vehicle. It was reported, "This study will have a much broader scope than a Mk 19 or a Modified Mk 12 study." The interest was in the use of three 400-lb warheads carried on the Minuteman III missile.

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Nova

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The Navy's Mk 400

The third-quarter report for 1972 from the Laboratory formally announced the Mk 400 program.[569] This program will be described in the following chapter.

SEV (Small Evader Vehicle)

The third-quarter report from the Laboratory also noted a program called the small evader vehicle (SEV) program. It was stated that LASL had supported this program with preliminary warhead data followed by a formal Mk 500 Phase 1 data package. Representatives from LASL had attended working meetings with the staff at McDonnell Douglas Astronautics Company.[570]

[Author's note: The Mk 500 was a Navy sponsored program. It was in a sense similar to the Mk 400, but the Navy wanted the Mk 500's missile to be able to change course on demand in order to attack the designated target.]

SCAD (Subsonic-Cruise Armed Decoy)

SCAD was envisioned to be a USAF turbojet-powered, air-launched, 800-mile-range missile designed to enhance bomber penetrations. The missile was to be carried on the B-52 and FB-111

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Reflecting the continuing interest in this type of weapon, in a February 28, 1972, memo, D. P. MacDougall reported that Giller had noted that he anticipated that a Phase 3 request might be initiated in the FY 1972–1974 time period for a Subsonic Cruise Armed Decoy (SCAD).[571]

In July 1972, the Director of Defense Research and Engineering (DDR&E) requested that the AEC reinitiate the Phase 2 study for the SCAD program. A March 1973 completion date was requested. The Laboratory's third quarter report states, "The original Phase 2 study for SCAD, requested by DDR&E in October 1970, was never officially initiated because the AEC did not receive an approved Phase 1 data package."

The third-quarter report from the Laboratory also notes, "LASL continues to study SCAD WH candidates that will best fit the SCAD missile and meet USAF requirements."[572]

The Laboratory's first-quarter report for 1973 indicates that for the SCAD Phase 2 input LASL had submitted four major proposals for the design

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[569]Leslie M. Redman and Cecil C. Carnes, Jr., "Quarterly Status Report on Weapons Research and Development for the Period Ending September 30, 1972 (U)," Los Alamos Scientific Laboratory report LA-5130-PR (SRD) (January 1973), p. 68.

[570]"Leslie M. Redman and Cecil C. Carnes, Jr., "Quarterly Status Report on Weapons Research and Development for the Period Ending September 30, 1972 (U)," Los Alamos Scientific Laboratory report LA-5130-PR (SRD) (January 1973), p. 70.

[571]D. P. MacDougall to Distribution, Subject: "Program Planning," ADW-204 (SRD) (February 28, 1972), 3 pp., B11, Drawer 49, Folder 1 of 5.

[572]Leslie M. Redman and Cecil C. Carnes, Jr., "Quarterly Status Report on Weapons Research and Development for the Period Ending September 30, 1972 (U)," Los Alamos Scientific Laboratory report LA-5130-PR (SRD) (January 1973), pp. 70–71.

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d. Projectiles and Earth Penetrating Weapons

Mark 48 Torpedo

The third quarter report for 1972 from the Laboratory notes that the input proposals for the Phase 1 study for the Mark 48 convertible warhead had been completed and submitted for review; the Phase 1 document had been published in August 1972. [Author's note: A convertible warhead was a warhead that could use a conventional HE warhead, or when required, this warhead could be exchanged for a nuclear warhead, or turned into a nuclear warhead.]

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It was suggested that the insertable-capsule concept could also be used in the Condor, Harpoon, and the extended-range Walleye. The Laboratory's quarterly status report for the period ending September 30, 1972, indicated that it was hoped that a nuclear test of a device representative of the insertable-capsule concept could take place before June 30, 1973.[578]

Harpoon

The Laboratory's fourth quarter report for 1972 indicates that the Laboratory had also been asked to participate in a similar Phase I study for a convertible warhead for the Harpoon, the Navy's new antiship missile. It was reported that the Los Alamos weapon development teams were investigating the feasibility of low-yield convertible warheads for this application.

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Additional information on the proposed design is available in the

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[578]Leslie M. Redman and Cecil C. Carnes, Jr., "Quarterly Status Report on Weapons Research and Development for the Period Ending September 30, 1972 (U)," Los Alamos Scientific Laboratory report LA-5130-PR (SRD) (January 1973), pp. 72–73.

cited reference.[579] (b)(3)

Penetrator

The third quarter report from the Laboratory indicates that Sandia was conducting an extensive study of earth-penetrating weapons. The staff at Los Alamos were reviewing this work.[581]

9. Conclusions

a. Work Load

As the reader will no doubt have realized from reading the previous sections, during the 1965–March 1973 time period there were an incredible number of Phase 1 and 2 projects that were requested by the various groups in the Military. As a result, a large amount of Laboratory effort must have gone into the preparation of suitable studies and proposals and attending meetings with the Military and their contractors. (John Hopkins has commented that one reason W-9 was formed was to respond to all the Phase 1 and Phase 2 requests made to the Laboratory.)[582] As reported in the previous sections, at times full-scale tests were also completed as part of these projects. However, despite all the effort and money spent on these, many of these projects never progressed into Phase 3 programs.

In addition to the Phase 1 and Phase 2 programs, there were other projects undertaken that the Laboratory management believed to be important in terms of weapon development. Some projects appeared to be important enough that the Laboratory management approved tests at NTS related to these programs. Many of the primary development tests described in Chapter II fall into this category.

b. Importance of the Work

There were a number of efforts that, one may conclude, ended as "dead end" projects.

However, if testing during this time period had been restricted to Phase 3 programs only, the Laboratory weapon development groups would not have been able to test the concepts that would later be incorporated into the XW76.

Thus, the fact that the test program at that time allowed for testing of advanced systems was important in future weapon development.

579Leslie M. Redman and Cecil C. Carnes, Jr., "LASL Weapons Quarterly for the Period Ending December 31, 1972 (U)," Los Alamos Scientific Laboratory report LA-5150-PR (SRD) (March 1973), p. 61.

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581Leslie M. Redman and Cecil C. Carnes, Jr., "Quarterly Status Report on Weapons Research and Development for the Period Ending September 30, 1972 (U)," Los Alamos Scientific Laboratory report LA-5130-PR (SRD) (January 1973), p. 73.

582John Hopkins, personnel communication (U) (November 21, 2002).

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Another figure of interest is the data on yield versus year shown in Figure V-7. As the reader will note, once megaton yield weapons were developed and entered the stockpile, there was a very rapid rise in the total stockpile yield. However, following the early 1960s, there was a continued decrease in yield as the smaller yield systems entered the stockpile.

Another item of interest is the use of special nuclear material.

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2. New Weapon Systems

Another interesting trend is the continuing decline in the number of new weapon systems coming into the stockpile as a function of year. The reader will recall that the first nuclear weapons had been employed in1945. The Phase 3 for the Mod 0 for the B61 was June 1963.

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During the latter half of the 1960s and early 1970s, despite all the work that had gone into the Phase 1 and Phase 2 projects, as previously noted, many of proposed weapons never reached Phase 3. Moreover, several of the Phase 3 programs were canceled before the weapon system went to the stockpile. After the award of the B61, the W62 (Minuteman's Mk 12 RV) went to Livermore. The Army's sponsored 63, 64, and 65 were never produced. The Army's W66 went to Los Alamos. The Air Force's W67 went to Los Alamos but was canceled. The Navy's W68 for Poseidon went to Livermore. The W69 for the SRAM missile went to Los Alamos. The W70 for the Army's Lan ' 1 t t Li did th W71 f th Army's Spartan missile

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Looking ahead in the period 1973–1980 the number of new systems was even more limited. The ABC program and Mk 18 programs (that evolved into the Mk 400 program) were precursors to the W76; the Phase 3 authorization for this strategic warhead was received by LASL in May 1973. The high-yield multiple RV program/Mk 19/Mk 12A was the precursor for the W78 (Phase 3, June 1974), an assignment that would also go to LASL. The High-Yield bomb program would go to Livermore as the XW77 with a Phase 3 of May 1974. (This program would later become the B83.) The Safeguard (Spartan/Sprint) program would be discontinued. (The weapons that had been stockpiled under this program would be retired.) The improved 8-inch artillery-fired projectile with a Phase 3 date of January 1975 would go to Livermore as the W79. The W80 program, the cruise missile project (air launch, sea launch, and advanced cruise missile) would receive a Phase 3 date of June 1976 and would go to Los Alamos.

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[redacted] The W82, a 155-mm artillery shell, was given to Livermore but was never produced. The W84, the ground-launched cruise missile warhead, would have a Phase 3 of September 1978 and would go to Livermore. The W85 for the Army's Pershing II missile went to LASL (Phase 3 of May 1979), but all warheads would be retired in March 1991 and their components used to build the B61-10 [redacted]

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The W86, the design for the Pershing II Earth Penetrator, was cancelled after Phase 3.[584] Thus, there were in a sense seven projects in seven years that reached the stockpile.

With few projects being awarded in this time period, it was a tough fight for the Laboratories to procure and complete a Phase 3 assignment.

3. Decreased Levels of Funding

Edward Giller, Assistant General Manger for Military Application, in a TWX dated September 17, 1970, reported to the Laboratories that the low level of FY 1971 on-continent funding as well as the trend being experienced in the overall level of funding meant that less money would have to be spent in the NTS test program than had been spent in previous years. Giller noted, "We must look both at the need for specific tests and test programs and at the way they are conducted. On the need side, we must candidly question such things as total numbers of tests being conducted on similar Phase 2 designs, on effects, or on high yield devices."[585] This was a notice that the NTS test program would need to undergo some changes. Tests would be limited to those considered to be the most important.

Giller continued his warnings to the Laboratories concerning the need to limit spending. In a document dated January 20, 1972, titled "FY-1974 Weapons Program Budget Planning Assumptions," Giller stated, "Any work which does not directly support either present or anticipated future weaponization requirements must be relegated to a lower priority category.

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[584]Betty L. Perkins, "Why Nougat? (U)," Los Alamos National Laboratory report LA-12950-H (SRD) (November 1, 1995), pp. A-1–A-3.

[585]USAEC, Edward B. Giller, Wash., D.C. to BW3, UCLRL, M. M. May, Livermore, Calif., et. al. (OUO) (September 17, 1970), 3 pp., A99-019, 198-12.

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seems to have an edge in experience, and hence, if the workload situation warrants it, the warhead might well be assigned to LASL."[4] In a letter dated June 1, 1966, to May, Bradbury conceded that if the Mk 3's warhead assignment were to be made soon, Livermore would get it. However, Bradbury stated, "If you end up doing the Mark 3, we would certainly insist that we should do the Mark 18."[5]

In a TWX dated June 23, 1966, Delmar L. Crowson, Director of Military Application, informed the laboratory directors that he had concluded that the designs utilizing the LRL proposals were the most suitable candidates for Phase 3 development of the Mk 3 warhead.

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Because of this, he was requesting that the Phase 3 assignment go to Livermore. (The warhead for the Mk 3 would be designated W68.) However, there were advantages to having different warheads be developed by different AEC laboratories. Crowson stated that he intended to assign the Mk 18 to Los Alamos.[6]

During the January 4, 1967, meeting of the Los Alamos WWG (Weapons Working Group), J. K. S. Walter reported that money had been budgeted for the Mk 18 program. However, final approval had not been received through the Air Force. Extensive briefings were scheduled to take place during the month. Interestingly, Walter reported that four warheads were being considered

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The maximum allowed weight was 150 pounds. As many as eight Mk 18 RVs were planned for use on a single Minuteman.[7]

In a memo dated January 16, 1967, the Chief of Staff of the Air Force noted that current plans were to start development of the Mk 18 Reentry System in FY68. The memo requested that a Concept Formulation Package for the Mk 18 aimed at Contract Definition in July 1967 be provided. The memo also noted that the programmed IOC (Initial Operational Capability) of the Mk 18 RV was July 1971. Although the previous 1966 study had been concerned with an Assured Destruction Mission, the new 1967 study was to also include the Damage Limiting aspect. Additional information on the desired inputs is available in the cited reference.[8]

2. The Question of the Primary

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It was noted, "They needed this information as soon as possible in order to proceed with systems effectiveness studies."

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[4]Michael M. May to Dr. N. E. Bradbury, BY 66-32 (SRD) (May 20, 1966), pp. 2–4, A99-019, 198-7.
[5]N. E. Bradbury to Dr. Michael M. May, DIR-2032 (SRD) (June 1, 1966), p. 1, A99-019, 186-2.
[6]USAEC, Delmar L. Crowson, Wash., D.C. to RUWPQA/USAEC L. P. Gise, Albuq., N.M. et. al. (SRD) (June 23, 1966), 3 pp., A99-019, 182-1.
[7]"Weapons Working Group, Minutes of the 170th Meeting," WWG-170 (SRD) (January 4, 1967), pp. 8–9, A99-019, 92-12.
[8]Chief of Staff, USAF to AFSC (SCL), Subject: "Mk-18 Re-entry System Trade-Off Analysis (U)," (SRD) (January 16, 1967), 4 pp., A99-019, 186-2.

attendees indicated that the Los Alamos team was to supply a partial input for the Mk 18 study by March 10. This input was to be followed by a more complete, Phase 2-like, document.[13]

On March 10, Walter sent a letter to Headquarters, Ballistic Systems Division that outlined the suggested Los Alamos designs for the Mk 18

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Walter's letter included schematics giving size dimensions of the various options. He noted, "All of the warheads proposed can be developed within the presently anticipated Mark 18 schedule."[14]

On March 14, 1967, Brig. General Delmar L. Crowson sent out a copy of a letter, dated February 17, 1967, from the Air Force to the Manager of the Albuquerque Operations Office as well as to the directors of the various AEC laboratories. In this Air Force letter Major General Otto J. Glasser, representing the Air Force, had requested that the Director of Military Application proceed with having the AEC laboratories participate in studies to optimize the Mk 18 RV configuration. He had reported that the Air Force intended to request a formal Phase 2 study as soon as the warhead requirements were better defined.[15]

During the March 15, WWG meeting, Shreffler reviewed the Mk 18 program

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The weapon groups were working on "Phase 2-like" documents. They hoped to have version two ready during the week of April 3.[16]

On April 25, 1967, the Los Alamos and Sandia planning team sent out a 29-page report titled "Technical Data Package for Mk 18 Systems Effectiveness Study." This report was similar to the March 10 proposal but included additional details in terms of weaponization

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[13]E. C. Dudziak, R. G. Shreffler, J. K. S. Walter, Subject: "Trip to BSD, Mark 18 Discussion," AW-1255 (SRD) (March 7, 1967), 5 pp., A99-019, 182-1.

[14]J. K. S. Walter to Headquarters, Ballistic Systems Division, W-1-E-12237 (SRD) (March 10, 1967), 10 pp., A99-019, 182-1.

[15]Brigadier General Delmar L. Crowson to Those Listed Below, Subject: "Mk-18 Reentry Vehicle," (SRD) (March 14, 1967), 1 p.; Otto J. Glasser to Director of Military Application (SRD) (February 17, 1967), 1 p., A99-019, 182-1.

[16]"Weapons Working Group, Minutes of the 174th Meeting," (SRD) (March 15, 1967), pp. 7–9, A99-019, 92-13.

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On May 16, in a meeting with Major L. H. Laird of BSD, Walter was told that the Phase 2 request for the Mk 18 had been turned down within the DOD pending completion of the Phase 1 package

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On June 1, 1967, Walter sent out yet another memo to his team. He noted the design characteristics of the reentry vehicle and the fact that seven vehicles per booster had been used in a recent study that had included an analysis of the weight vs yield as a function of design. As part of Walter's memo, the results of the study showing RV weight vs yield were presented in the form of graphs.[21]

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During the WWG meeting of June 7, Walter announced that the Air Force Weapons Laboratory was currently putting together the Mk 18, Phase 1 package. It should be available later in the week.

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The WLPC meeting held on June 13, 1967, was, from a historical point of view, a very interesting one. It was called to discuss possible primaries for the Mk 18. During the meeting, it was announced that the Phase 1 package in draft form was available.

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[21] J. K. S. Walter to Distribution, Subject: "Mk 18 Design Study," W-1-E-12492 (SRD) (June 1, 1967), 11 pp., A99-019, 182-1.

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On June 19, R. G. Shreffler, Alternate W-Division Leader, sent out a memo to upper management,

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During the July 6, 1967, WLPC meeting, it had been announced that the Mk 18 program had slipped about 9 months; a Phase 2 date was not predictable.[30]

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(b)(3)

In order to take advantage of your experience in this field as rapidly as possible, I suspect that we will want to have a good many conversations with various members of your staff familiar with the various problems you have encountered. We will try to be as little trouble to you as possible, but I hope we may count on your assistance, and the purpose of this letter is to request this!"[34] In a letter dated August 23, 1967, May agreed to assist. He noted, "A potentially mutually advantageous diagnostic program regarding these primaries would be their flash X-ray analysis on your superior Phermex facility."[35]

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[Author's note: LX-09 was a Livermore developed formulation. The Livermore scientists felt, at that time, that this explosive was stable at relatively high temperatures.] A. Popolato from GMX-3 announced to the HWG attendees that the Los Alamos explosive formulation staff had also developed an explosive that performed as well as LX-09 at high temperature. This explosive was going to be known as PBX 9408.

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[34]N. E. Bradbury to Dr. Michael M. May, DIR-2091 (SRD) (August 17, 1967), 1 p., A99-019, 182-1.
[35]Michael M. May to Dr. N. E. Bradbury, Director, BY #67-55 (SRD) (August 23, 1967), 1 p., A99-019, 273-2.

(b)(3)

At the WLPC meeting of November 9, 1967, Deal announced that the Los Alamos group had seen a draft of a Phase 2 letter on the Mk 18.

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The group agreed that this reflected the opinion of the members present."[44]

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[44]"Hydrodynamics Working Group, Minutes of the 32nd Meeting, November 9, 1967," HWG-32 (SRD) (November 9, 1967), pp. 7–8, A99-019, 76-19.

ever, is a long way off. We can do anything if it takes forever." [Author's note: This proposal was apparently in some measure an attempt to discourage Livermore from trying to "grab" the program.] Agnew reported that Giller had stated that he expected LASL to do the Mk 18.[51]

Agnew won his committee and a Mk 18 SPO-like group was indeed formed. The first meeting was arranged for February 13, 1968, at the Aerospace Corporation. By the time the group was set up, the mission/candidates for the Mk 18 program had become much more diverse than had been the case in the fall of 1967. Additional information is available in the cited reference.[52]

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The first Mk 18 "SPO" meeting was held as scheduled. The attendance list shows a large number of people present from SAMSO, FC/DASA (Field Command, Defense Atomic Support Agency), AEC/ALOO, AFWL, LASL, Sandia, TRW (Thompson, Ramo & Woolridge), DMA, and Aerospace. The LASL report of the meeting notes, "Fortunately, the subject of Livermore participation did not come up." The LASL report also states, "The first meeting was unfortunately too large to achieve an across-the-table atmosphere." The next meeting was to be at LASL on March 26, 1968.[54] (This meeting was actually held on March 29 at LASL. Among those in attendance was a representative from LRL as well as representatives from Sandia, ALO, FC/DASA, DMA, AFWL, SAMSO, Aerospace and TRW.[55]) The group became known as the Mk 18 Technical Planning Group.

During the February 21, 1968, meeting of the WWG, in response to the fact that the Mk 18 program had become a very general one, Bradbury commented that the Laboratory better pursue "all versions of the Mk 18."[56]

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[51]H. M. Agnew to Distribution, Subject: "Meeting at AFWL," W-2082 (CRD) (January 8, 1968), 2 pp., A99-019, 182-2.

[52]J. K. S. Walter to Distribution, Subject: "Trip Report; Reentry Systems Advisory Group Meeting, January 18; Mk 18 Meeting at Aerospace Corporation, January 19, 1968," W-1-E-13191 (SRD) (January 30, 1968), 3 pp., A99-019, 182-2.

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[54]J. K. S. Walter, W-9 to H. M. Agnew, W-DO, Subject: "First Mk 18 'SPO' Meeting; Aerospace Corporation; February 13, 1968," W-9-14 (SRD) (February 16, 1968), 4 pp., A99-019, 182-2.

[55]J. K. S. Walter, W-9 to Distribution, Subject: "Mk 18 Technical Planning Group Meeting March 29, 1968," W-9-48 (SRD) (March 26, 1968), 3 pp., A99-019, 182-2.

[56]"Weapons Working Group, Minutes of the 189th Meeting," (SRD) (February 21, 1968), p. 14, A99-019, 92-15.

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By July, it appeared that a decision might be made soon on moving ahead on the Mk 18. Walter had once again attended a meeting held on June 28, 1968, at Aerospace Corporation. Walter stated in his trip report, "Because of very recent indications that the Mk 18 may move ahead on the schedule outlined in the Concept Formulation Package (Contract Definition in FY 1969 and IOC [Initial Operational Capability] in December 1972), a meeting was called by SAMSO in order to provide an AEC briefing to the Minuteman people in SAMSO and TRW."

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4. The Question of the Secondary

In an August 9, 1968, memo, secondary designer, A. T. Peaslee, Jr. (T-2), reported on the problems the secondary designers were having in the design of the Mk 18 secondary

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(b)(3)

5. Where Do We Go From Here?

The fifth meeting of the Mk 18 Technical Planning Group was held on October 4, 1968.

(b)(3)

There is the possibility that some other number will be assigned to the reentry system."[74] [Author's note: There is no information, that the author could find in the Los Alamos files, as to why after the Secretary of the Air Force briefing on July 11 the expected approval was not forthcoming.]

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[74] J. K. S. Walter, W-9 to Distribution, Subject: "Trip Report; Mk 18 Technical Planning Group; AFWL; October 4, 1968," W-9-251 (SRD) (October 8, 1968), 3 pp., A99-019, 182-3.

(b)(3)

Walter then closed his letter by stating, "It is difficult, and perhaps unwise, to make the laboratory development program responsive in detail to the excursions encountered in the Mk 18 program."[75]

(b)(3)

In mid-November 1968, a Mk 18 concept briefing was given to the Air Staff and Air Force Systems Command by representatives from the Space and Missile Systems Organization (SAMSO).

(b)(3)

The Air Staff was in the process of compiling and publishing a final Concept Formulation Plan. If events moved smoothly, an Initial Operational Capability in the last quarter of 1973 appeared possible.[79]

The sixth Technical Planning Group meeting for the Mk 18 was held on December 3, 1968.

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[75] J. K. S. Walter to Headquarters, Space & Missile Systems Organization (SMQ), Subject: "Mk 18," W-9-268 (SRD) (November 5, 1968), 4 pp., A99-019, 182-3.

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[79] "Weapon Development Status Report," Headquarters Field Command Defense Atomic Support Agency, Sandia Base, Albuquerque, New Mexico report FC12680581 (SRD) (December 19, 1968), p. 19, A99-019, 161-1.

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Additional information is available in the cited reference.[80]

(b)(3)

[Additional information is available in Chapter II.]

(b)(3)

A document titled "Mk 18 Description, Planning Information" was circulated in February 1969. This was described as an update to the December 6, 1967, planning document. The warhead had the dual roles of Assured Destruction and Damage Limiting Missions. Included in the document was information on the proposed warhead.

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Additional information is available in the cited reference.[82]

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Three RVs were to be used per booster.

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[80] J. K. S. Walter to Aerospace Corporation, Subject: "Mk 18," W-9-291 (SRD) (December 16, 1968), 11 pp., A99-019, 182-3.

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[82] "Mark 18 Description, Planning Information," U.S. Atomic Energy Commission, Albuquerque Operations Office document, (SRD) (February 1969), 26 pp., A99-019, 182-3.

(b)(3)

To further add complexity as to what design would be used in the Mk 18 warhead, there continued to be interest in the use of eleven RVs per booster.

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One can see that the Military at this time might have been somewhat disappointed in the Los Alamos program for the Mk 18.

(b)(3)

6. Phase-Out?

On August 15, 1969, representatives from LASL and SLA presented a briefing on the Mk 18, Mk 19, and Mk 12A warheads at SAC (Strategic Air Command) Headquarters. In his trip report, H. C. Hoyt stated, "SAC believes that there is a rapidly increasing need for the capability to kill hard targets. (b)(3)
Hoyt also noted, "They don't believe that the Mk 18 gives any significant improvement over the Mk 12 for softer targets, and so they are not interested in the Mk 18." The SAC people also appeared to be uninterested in a warhead replacement for the Mk 12A

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He recommended that the Mk 19 effort be given priority over the Mk 18 effort.[88]

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[88] H. C. Hoyt, W-DO to Distribution, Subject: "SAC Missile W/H Requirements," AW-1328 (SRD) (August 20, 1969), 2 pp., A99-019, 182-4.

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In a TWX dated September 15, 1970, Bergen noted that the Mk 18 and Mk 19 had been studied in detail for use on Minuteman III.

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The meeting minutes report, "This is probably the last MK 18 shot to be fired."[98] (b)(3) One reason for this long delay may not only have been technical but also political; Los Alamos had failed to obtain a Phase 3 assignment for the Mk 18. (b)(3)

In a July 27, 1971, memo, W-9's C. M. Gillespie reported that the Mk 18 program was now the ABC program (the Advanced Ballistic Concept program) (b)(3) The program's objective was to provide an RV of 200 pounds or less for MIRV application to either Minuteman III or Poseidon (although the Navy did not appear interested). (b)(3) Gillespie in his memo states, "The program is

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[98] "Weapons Working Group, Minutes of the 230th Meeting," (SRD) (March 17, 1971), p. 9, A99-019, 92-18.

in a flight hardware development phase with two flight tests scheduled as well as underground vulnerability tests."

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7. **Transformation**

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B. Mark 400 Program

1. Livermore vs Los Alamos: The Navy's Submarine-Launched Ballistic Missile (SLBM) Warheads—W47, W58, and W68

Navy planners and others realized that a ballistic missile outfitted with a nuclear warhead that could be launched from a nuclear submarine presented a weapon system that could be highly effective as a deterrent. This concept was placed into practice with the development of the first SLBM nuclear warhead: designated the W47. This warhead was designed for use with the Navy's Polaris A-1 and the Polaris A-2. It first entered the stockpile in June 1960. There were several modifications made in the warhead during its stockpile lifetime. The next warhead placed into deployment on a submarine-launched ballistic missile was the W58. This was used in the Mark 2 reentry system fitted on the Polaris A-3; this missile could carry three warheads. The weapon development groups at Livermore were responsible for these early warheads. The Lockheed Missile and Space Company (LMSC) carried the major responsibility for the carrier of the warhead(s). A detailed account of the development of the W47 and W58 is given in LA-13755-H (SRD). During the development of these systems, a close relationship was established between Livermore, Lockheed, and the Navy.

The early Livermore–Lockheed–Navy association was a close one. However, the administration at Los Alamos very much wanted to be included in this group. One way to get a foot in the door was to have Los Alamos people present at planning meetings. [Author's note: It should be noted that as an exception Ralph Williamson from T-2 participated in the group known as the Polaris Ad Hoc Group for Long Range Research and Development. He appears to have attended the meeting held on April 29–30, 1965, at the Naval Research facilities in Washington.[106] Although documentation is lacking, he probably attended similar meetings held at other times.]

In the fall of 1965, Al Bridges from Kaman Nuclear visited Los Alamos. At that time a request was made to him to have representatives from Los Alamos participate in the Navy's planning meetings. [Author's note: The administration at Los Alamos must have known that the Navy was interested in developing a new ballistic missile/submarine system to be called Poseidon.] On December 6, 1965, the Chief of Naval Operations requested that the AEC laboratories be authorized to cooperate with the Navy in joint conceptual studies leading to the determination of optimum parameters for various components of the Poseidon missile. This request in turn led to the inclusion of Los Alamos in a memo from Brigadier General Delmar L. Crowson, Director of Military Application. Crowson requested that the Sandia Corporation, the Los Alamos Scientific Laboratory, and the Lawrence Radiation Laboratory participate with the Navy in these requested conceptual studies.[107]

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[106]Chairman, Polaris Ad Hoc Group for Long Range Research and Development (PLRRD) to Distribution, Subject: "PLRRD Meeting 29-30 April 1965," SPOO110/RHY:md 3900 (U) (March 31, 1965), 1 p., Ralph Williamson papers, A86-049, 1-1.

[107]Brigadier General Delmar L. Crowson to L. P. Gise, Subject: "Joint AEC/Navy Conceptual Studies for Optimization of Poseidon Missile System," (SRD) (December 22, 1965), 1 p. and enclosure, A99-019, 217-15.

Projects Office Sunnyvale (SPL), and FC/DASA (Field Command, Defense Atomic Support Agency).[112] Thus, Los Alamos was again "out of the loop" at this point.

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The history of the Livermore design effort for the W68 is available in LA-13755-H (SRD). The weapon entered the stockpile in 1970. (b)(3) The warhead was a component in the Mk 3 RB (reentry body) carried on the Navy's Poseidon C3 missile

(b)(3)

Thus, the weapon could be used for single-target or multiple-target missions.

The Williamson papers available in the Los Alamos archives include a brief note made by Williamson on December 6. 1966

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Figures showing the design of several of these are available in LA-13755-H (SRD).]

2. Advanced Planning: 1966–August 1969

Advisory groups, called the Advanced Technical Objectives Working Groups (ATOWG), were initially established during a meeting of the Laboratory directors on June 7, 1966. The reason for these groups was reported: "The combined weapons, engineering and research experience of the laboratories represents a fundamental resource necessary to military system concept formulation. The nine Naval warfare area working groups were established to capitalize on this collective expertise." [This author believes that Williamson was appointed in 1966 to be a member in these groups.] The first of a series of reports prepared by these groups was distributed in the spring of 1967.[114]

During March 23–24, 1967, Williamson attended a meeting of the Committee on Advanced Concepts for Sea Based Deterrence. It was reported that a document titled "Advanced Missile Technology" had been issued on March 3.[115]

[112] "Weapon Development Status Report (U)," Headquarters Field Command Defense Atomic Support Agency, Sandia Base, Albuquerque, New Mexico report FC-08660494 (SRD) (August 18, 1966), p. 6, A99-019, 160-4.

(b)(3)

[114] Gerald W. Johnson, Department of the Navy, Director of Navy Laboratories, "Memorandum for Chairman and Members of the Advanced Technical Objectives Working Groups," (U) (August 8, 1967), 1 p., Ralph Williamson papers, A86-049, 1-1.

[115] "Committee on Advanced Concepts for Sea Based Deterrence, Minutes of Meeting 23-24 March 1967," (U) (no date), p. 1, Ralph Williamson papers, A86-049, 1-1.

range would provide a greater weapon system capability in the face of a potential ASW (Anti-Submarine Warfare). Baker, in his trip report, noted that representatives from LMSC had given most of the presentations. The LMSC group had reported on the minimum modifications necessary in the Mk 3 to permit improved performance. [Author's note: Sybil Francis in her report on Livermore has indicated that the SSPO group did not want a new warhead for the new missile; they preferred at that time to use a modified Poseidon warhead. This choice would minimize RB and warhead development costs and would avoid costly flight testing.[119] C. M. Gillespie in a May 17, 1972, memo also stated, "In the Mk 400 program SSPO has always wanted the W68 as the warhead and LLL as the laboratory."[120] Additional information on this issue is presented in several of the following paragraphs.] During the September 15 meeting, it was reported that the LMSC/Navy had requested data packages from LASL/SLA and LRL/SLL covering warhead yields from 20 to 1,000 kt. Navy representatives hoped to use their old data coupled with this new input information to "come up with an optimized system." Navy representative Commander Stinner warned, however, that the Navy's funding for ULMS was minimal. He noted that the members should not return to their respective organizations and build large budget ULMS programs quoting SSPO justification.

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The Los Alamos group also provided information on the Mk 18 test program and indicated that this program was relevant to the warhead study for the Advanced Poseidon System. During the discussions, it was indicated that the high-risk, long-lead technological changes appeared to be the submersible and the submersible/missile interface. It was noted that the entire project hinged on the availability of a new sub that would accommodate a 48-foot by 100-inch missile. At the meeting's close, it was agreed that it was important to have formal meetings and full participation by the member organizations in order to exchange the necessary technical data.[121]

On November 19, 1969, the requested LASL/SLA data package was submitted to H. D. Trudeau at LMSC. Eight proposed Los Alamos designs were described in terms of yield, size, weight, center of gravity, and moment of inertia.

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The document would also note that an integrated arming, fusing,

[119]Sybil Francis, *Warhead Politics – Livermore and the Competitive System of Nuclear Weapon Design*, Massachusetts Institute of Technology thesis document (U) (September 1995), p. 155, Los Alamos archives.

[120]C. M. Gillespie, W-9 to Distribution, Subject: "Draft of Mk 500 Phase 1 and 2 Program Proposal," (SRD) (May 17, 1972), p. 2, B11, Drawer 56, Folder 1 of 4.

[121]F. B. Baker, W-9 to H. M. Agnew, W-DO, *Subject: "Trip Report – Meeting of the Re-entry Committee* of the FBM Steering Task Group at LMSC, Sunnyvale, California 9/15/69," W-9-511 (SRD) (September 29, 1969), 1 p., A99-019, 307-3. "Minutes of the Re-entry Committee of the Fleet Ballistic Missile Steering Task Group Meeting (U)," Kaman Nuclear report KN-69-440(R) (SRD) (September 29, 1969), 123 pp., A99-019, 163-6.

(b)(3)

and firing (AF&F) system incorporating component technology developed during the Mk 3 program and other recent advanced development programs could be supplied.[123]]

The second meeting of the Re-entry Committee of the Fleet Ballistic Missile Steering Task Group was held on January 28, 1970, at the Naval Ordnance Laboratory (NOL) in Silver Spring, Maryland. It was reported that performance goals of the new ships to replace the Polaris/Poseidon ships were beginning to be outlined. The new ships would be on patrol 80% of the time with an 83-day patrol period. They would have a 7–15 db noise level below the present ships. They would include a long-life nuclear reactor. They would be designed with a collapse depth of 1,350 feet. For the missile launcher system, the tube dimensions being considered were a diameter of 115 to 135 inches and a length of 50 feet. The ships would each be capable of carrying twenty-four missiles. Each missile would have a minimum missile range of 4,500 nm. It was the missile that would be the determining factor in the size of the submarine. The missile candidates at that time ranged from the 34-foot long, 74-inch diameter C3 missile to a proposed 49-foot long 110-inch diameter missile. Several ship designs were under consideration, including a single hull vs several types of double hull configurations. Decisions still to be made included the number of missiles a ship should carry, launch tube diameter, launch conditions, number of people on each sub, shipboard environment requirements, ship/missile accuracy, and maintenance. The schedule then under consideration called for a nominal number of new-class ships by FY 1978. In terms of improvement in the warhead, it was indicated that with a suitable timeframe available for development, an explosive electric generator could be manufactured reliably. This type of generator would reduce the need for high currents for ignition. Improvements in CEP [circular error probability] were also possible. It was also reported that by using large reentry angles, high ballistic coefficients, and low radar cross sections, the offense could reduce the defense's engagement time. Hardening options were also presented at the meeting. It was recommended that the Navy spend "time and effort pursuing hardened system designs."[124]

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Although not part of the Mk 400 program, it will be noted that in the summer of 1970, the Navy was also interested in a program called CAFE. This stood for C-3, Alternate, Front End.

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/[Author's note: There was concern at that time that, due to political considerations, that the use of the Mk 3/W68 (MIRV) might be restricted or abolished.] The first CAFE Reentry Interchange Committee Meeting took place on July 15, 1970. The LASL/SLA laboratories submitted data for the CAFE study in a document dated August 7, 1970. The principal warhead proposal from LASL was the use of a W67-like device. It was noted, "Many of the development tests, up to flight tests, have been completed for this device; construction drawings are available." Use of a 16M type of device was also

[123] "LASL/SLA Revised Data Package for ULMS (Undersea Long Range Missile System) Study," W-9-754 (SRD) (September 1, 1970), 12 pp., A99-019, 214-15.

[124] "Minutes of the Second Re-entry Committee of the Fleet Ballistic Missile Steering Task Group Meeting (U)," Kaman Nuclear report KN-70-68 (R) (SRD) (February 7, 1970), 178 pp., A99-019, 163-6.

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suggested. Although the high-yield Poseidon warhead would never become part of the stockpile, it is interesting to note that Los Alamos and Sandia Albuquerque were involved in the CAFE program.[126] The close connection between LMSC, Livermore, and the Navy was becoming less restrictive. (Additional information on the CAFE program is available in the Los Alamos archive files.)

In a TWX dated August 6, 1970, H. C. Donnelly, manager of the AEC Albuquerque Operations Office, noted that the DMA (Division of Military Application) had requested that the Los Alamos/Sandia group provide, for planning purposes, by September 8, 1970, a single design for the ULMS application. However, Donnelly warned, "The selection of a Laboratory as a source of design information on a system for this purpose is in no way intended or expected to prejudice the future selection of a Laboratory to develop the system."[127] In response to this request, Los Alamos document W-9-820, dated September 10, 1970, was prepared and sent to Donnelly.[128]

The third meeting of the Reentry Committee Fleet Ballistic Steering Task Group Meeting was held at Livermore on November 5, 1970. Attendees from Los Alamos were T. A. Sandford (GMX-3), D. W. Bergen (W-9), F. B. Baker (W-9), R. J. Young (T-2), and E. A. Bernard (W-4). During the meeting, J. Marion from Livermore reviewed Livermore's small-weapon design effort.

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Representatives from LMSC discussed representative RB/bus layouts. It was noted that range extension, achieved by placing a rocket motor on the bus and clustering the RBs around the motor, was being studied. The current objectives for ULMS were then listed.

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Seventy-four percent of the fleet was to be at sea all the time. Because a 14-day refit time in port was desired, modular maintenance of the system would be important.

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It was reported that the submarine was going to be the pacing item. Representatives of LMSC discussed their ballistic RB studies. It was noted that because a definite mission had not yet been specified for ULMS, LMSC personnel were studying a wide variety of yields, weights, ballistic coefficients, hardness levels, and materials. It was noted that use of the existing Mark 3 would require a minimum modification.

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R. R. Neel from SLA discussed blowoff from filament reinforced heat shields. Neel's presentation was followed by a discussion from the LMSC representatives on the materials that they were interested in for heat shields and nose tips. In concluding his trip report, Sandford

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[126]Floyd B. Baker, Group W-9 to Mr. C. E. Grant, Lockheed Missiles and Space Company (SRD) (August 7, 1970), 1 p. and enclosure W-9-796, A99-019, 79-9.
[127]USAEC, H. C. Donnelly, Mgr., Albuquerque, N.M. to C13/LASL, N. E. Bradbury, Dir. et. al. (SRD) (August 6, 1970), 4 pp., A99-019, 214-15.
[128]Herman P. Deinken to Mr. H. C. Donnelly, Subject: "Joint LASL/SLA Design Information for Long Range Planning," (U) (September 10, 1970), 1 p., A99-019, 214-15.

complained that the LASL attendees had been given little opportunity to make presentations. Sandford suggested that perhaps the next meeting could be held at Los Alamos.[129]

A rather comprehensive document titled "Planning Information Document for Underseas Long-Range Missile System (ULMS)" was issued in the final quarter of 1970 by the Albuquerque Operations Office. This document incorporated the information contained in W-9-820. The document noted that the ULMS was a submarine-launched missile system that included a new design submarine as the launch platform and a new longer-range missile.

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The layout of the proposed warhead, including material quantities, is shown in Figure 2 of the Operations Office report. The report includes other details of the design and further detailed information.[130] [Author's note: The reader will note that this design historically is applicable to the W78.] Almost a year later, on October 8, 1971, Herman P. Deinken, Assistant Group Leader of W-9, would write Donnelly informing him that the LASL staff had reviewed the planning document and, as a result of updated information, the staff wanted several changes incorporated.[131]

On January 13, 1971, F. Baker, C. Gillespie, E. Bernard from LASL, and B. R. Emrick from SLA attended a meeting at LMSC to discuss the progress of the concept paper on ballistic RBs for the ULMS. The group was informed that the study had been completed and was scheduled for distribution. The purpose of the study had been to determine what yields, hardness, heat shield, and related components should be studied in detail if ballistic RBs were chosen for the ULMS mission. Another concept paper was being prepared by staff at LMSC. It was also noted during this meeting that there appeared to be increasing Navy concern over boat survivability. As a result, a Poseidon Extended Capability Study (PECS) was to be made. This study would include a feasibility study of the possibility, in order to increase the range of the missile, of removing the four central RBs carried on the present missile and replacing them with an additional bus engine.[132]

On February 9, 1971, Baker again visited LMSC for the purpose of discussing the PECS study. He was informed that the PECS had turned into the EXPO (Extended Poseidon Operation.) The scope of the study had been enlarged to include consideration of a new warhead as well as a new heat shield on the RB. The main objective of the study was to show how best to fill the gap between the present 1970 Poseidon and the proposed 1980 ULMS system. The two warhead options being considered for EXPO were to retain the W68 or to develop a new warhead.

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[129] T. A. Sandford to Jesse Aragon, Subject: "Third Reentry Committee Fleet Ballistic Steering Task Group Meeting (U)," GMX-3-9191 (SRD) (November 13, 1970), 4 pp., A99-019, 82-23.

[130] "Planning Information Document of Undersea Long-Range Missile System (ULMS)," AEC Albuquerque Operations Office document PID-9-00 (SRD) (October 1970), 24 pp., A99-019, 214-15.

[131] Herman P. Deinken to Mr. H. C. Donnelly, Subject: "Long Range Planning Warhead Data for HYB, ULMS and SCAD," (SRD) (October 8, 1971), 3 pp., A99-019, 214-15.

[132] F. B. Baker and C. M. Gillespie, W-9 to L. C. Horpedahl, W-9, Subject: "Trip Report: Lockheed Missiles and Space Company (LMSC), ULMS Discussion – January 13, 1971," W-9-943 (SRD) (January 25, 1971), 3 pp., A99-019, 307-5.

(b)(3) The extended range for EXPO would come by replacing the four central RBs in the C-3 bus with a 3,000-pound motor. There was also consideration being given to modification of the submarine to carry a 37-foot missile as compared to the present 34-foot missile.[133]

The fourth Reentry Committee Meeting of the Fleet Ballistic Missile Steering Task Group was held at the LMSC facility in Sunnyvale, California, on March 30, 1971. During the meeting, C. M. Gillespie, representing the Los Alamos Laboratory, discussed the Los Alamos program relevant to the ULMS program.

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Hugh R. Lehman (W-9) discussed his vulnerability work and noted that he felt that the neutron vulnerability of nuclear weapons was an important issue. He reported, "...in the ULMS era some sort of terminal [USSR] ABM system may exist in large numbers sufficient perhaps to exhaust our surviving retaliatory RBs."[135]

Baker returned to LMSC for a visit on April 14, 1971. After his visit, he reported that consideration of a new warhead in the EXPO study had been eliminated; only the W68 in a new RB would be considered in the final report. This decision had come from the SSPO office in Washington. Baker noted that the restriction to the use of the W68 warhead was probably more political than technical. However, in terms of time constraints, Baker reported, "...there is time to make a case for a new warhead to meet this IOC [Initial Operational Capability] of 1976." Baker included in his trip report a list of questions that should be addressed if a new warhead were to receive any serious consideration for use in an EXPO missile. Baker also reported that the design constraint in the Poseidon envelope would permit a new second-stage motor and an increase of about 2 feet in the overall length of the missile.[136]

On April 27–29, 1971, C. M. Gillespie attended the meeting of the Advanced Technology Working Group for Sea-Based Deterrence. He noted in his trip report that he was replacing Ralph Williamson as the Los Alamos representative. Gillespie indicated that the Navy was aiming for approval of a Development Concept Paper for the ULMS by January 1, 1972. Gillespie reported that this paper would outline "what the system is all about and how one is going to get it." The proposed project was not cheap—the R&D costs alone for the ULMS system including boats, missile, guidance, and related equipment was estimated at 1,900 million

[133]F. B. Baker to L. C. Horpedahl, Subject: "Trip Report: Visit to Lockheed Missile and Space Company (LMSC). Poseidon Extended Capability and ULMS, February 9, 1971", W-9-970 (SRD) (February 17, 1971), 2 pp., A99-019, 307-5.

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[135]Hugh R. Lehman, Group W-9 to Kaman Sciences Corporation, Subject: "Transmittal of Presentation," (SRD) (April 21, 1971), 1 p., plus enclosure W-9-1040, A99-019, 82-23.

[136]F. B. Baker to L. C. Horpedahl, Subject: "Trip Report – Visit to LMSC on EXPO, April 14, 1971," W-9-1044 (SRD) (April 26, 1971), 3 pp., A99-019, 307-5.

boat was to be six years after the IOC of the missile.

(b)(3)

The Packard memo had also asked the Navy to consider an optional RB that had a maneuvering capability.[147]

(b)(3)

[Author's note: This was good news for the Los Alamos group. It appeared that a Los Alamos proposal was being used in the RB design studies.]

There was also the Small Evader Experiment (SEE). During the October 20, 1971, meeting of the WWG, Gillespie informed the attendees that SEE was a minimum-weight, minimum-size maneuvering warhead for Poseidon. General Electric personnel planned to have the SEE project in a study phase through December; flight tests were to begin as quickly as possible after that.

(b)(3)

Gillespie reported that the LASL group felt that they had a better design for this application. Gillespie also reported on the EXPO program. He noted that EXPO had, in essence, been renamed ULMS. The Phase 1 would require a new missile for the Poseidon boat; two alternative missile developments were desired.

(b)(3)

For this system, the Navy's SSPO was trying to avoid the usual Phase 2 program by repackaging the W68 as the warhead. The second alternative missile development would be concerned with a missile that would carry a maneuvering reentry system similar to SEE.[149]

On October 20, 1971, a meeting was held at the Sunnyvale offices of LMSC. T. P. Seitz and F. B. Baker from W-9 were the Los Alamos attendees. Their trip report indicates that the discussions centered on the status of the ULMS.

(b)(3)

The reentry body was limited to a weight of 170 pounds, a length of 65 inches, and a diameter of 15.8 inches.

(b)(3)

[147]C. M. Gillespie, W-9 to Distribution, Subject: "Imminent Phase 2 on EXPO-ULMS," W-9-1185 (SRD) (September 23, 1971), 1 p., A99-019, 214-15.

(b)(3)

[149]"Weapons Working Group, Minutes of the 234th Meeting," WWG-234 (SRD) (October 20, 1972), pp. 10–12, A99-019, 92-18.

(b)(3)

study had been prepared but was still "circulating in the Navy chain of command." They too reported that the base-line WH was the W68. Their trip report notes, "A new WH will not be seriously considered unless it allows the RV to be substantially (how much is not known) lighter, smaller, or to carry a higher yield." [Author's note: Thus, if LASL were to receive this much-desired assignment they were going to have to come up with, and sell, a much different warhead than Livermore's W68.] The Sandford/Gillespie trip report also noted that the requirement that was going to be part of the MCs (Military Characteristics) was that the RV had to survive a 66-foot drop onto a submarine deck. (The Navy had wanted a 110-foot requirement, but they had been talked out of it.)[156] For additional information on the Donnelly and LASL reports, the reader may refer to the cited documents.

There were several official documents issued during November. The NAVPRO Document No. 8822 (006), dated November 12, 1971, reported on the stockpile-to-target sequence. The minutes of the Mk 400 AEC/DOD Coordination Meeting held on November 12, 1971, at Livermore and the Kaman Science document K-22896 dated November 15, 1971, reported on program guidelines and the draft Military Characteristics.[157]

(b)(3)

/The team then went on to specify the preliminary details of the design. Final specifications of the design were to follow after the required GMX field tests and the more detailed design studies had been completed.[158]

In a memo also dated November 17, 1971, Assistant Director for Weapons MacDougall indicated that it appeared that a request for a Phase 2 study for the warhead for the ULMS would be made in the near future. Milt Gillespie from W-9 had been designated as the coordinator of this study.[159] The Mk 400 Phase 2 study was again discussed during the WLPC meeting of November 22, 1971. The meeting minutes report, "It is admitted that the chance of our being selected to do the Phase 3 job for the warhead for the Mk 400 RB is small, but there are a number of reasons why we must participate and do a credible job on the Phase 2 study. ...The schedule suggested by the Navy for the Mk 400 Phase 2 study is very short and perhaps not entirely realistic, but we will do our best."[160]

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[156] T. A. Sandford and C. M. Gillespie to Distribution, Subject: "ULMS Meeting (U)," GMX-3-9870 (SRD) (December 3, 1971), 5 pp., A99-019, 214-15.

[157] "Report of Impact and Capabilities Study for the Mk 400 Reentry Body for Poseidon C-4 and Trident (Previously ULMS)," Draft, AEC Albuquerque Operations Office report I&C No. 5-72 (SRD) (July 1, 1972), p. 6, B11, Drawer 56, Folder 1 of 4.

(b)(3)

[159] D. P. MacDougall to Members, WLPC, Subject: "Topic for Next Meeting," ADW-162 (CRD) (November 17, 1971), 1 p., A99-019, 214-15; also in A99-019, 91-11.

[160] D. P. MacDougall to Members, WLPC, Subject: "WLPC Meeting No. 78, November 22, 1971," ADW-166 (SRD) (November 23, 1971), p. 1, A99-019, 91-11.

The Navy awarded the prime development contract to LMSC before the end of November. By that time, the Navy SSPO office had outlined a development schedule that included Phase 2 approval by SSPO by February 1972 and a Phase 3 request to DMA by April 15, 1972. The FPU (First Production Unit) was scheduled for November 1976.[161]

On December 7, 1971, W. J. Rudy and J. E. Gordon from Kaman Sciences Corporation (KSC) met at Los Alamos with several of the LASL theoretical staff. The reason for the meeting was for Rudy and Gordon to outline the Mk 400 hostile environment as currently being recommended by LMSC and KSC. The KSC representatives indicated that they would return to Los Alamos early in January to receive comments prepared by the Los Alamos group. The KSC staff would then circulate a final draft report. They would return once again in February for comments on this draft report before they published the completed hostile environment report.[162]

During the December 8, 1971, meeting of the WWG, Hoyt listed some of the shots proposed for FY73.

(b)(3)

Also, there was a meeting at LMSC on December 8, 1971. ~~Meeting with the LMSC~~ representatives were F. B. Baker, F. W. Kramer, B. E. Hoverson, and R. B. Olwin from Los Alamos and P. L. Brown, R. L. Alvis, and W. R. Green from SLA. It was reported that three topics were discussed, (1) Los Alamos/Sandia input data for the C-4/Mk 400 study, (2) the C-4/Mk 400 Design Matrix, and (3) the enemy defense model.

(b)(3)

It was reported that reentry body designs based on these were being prepared by the LMSC staff.[164] After this meeting, drawings containing warhead data for the proposed Mk 400 were sent from Sandia/Los Alamos to Lockheed personnel.[165]

A new planning information document, a successor to the one published in the latter part of 1970, was issued by the AEC in December 1971.

(b)(3)

[~~Author's note: However, the cover letter for the document indicated that "the nuclear system~~ described is not applicable to ULMS I."[166]] It was reported that a yield for the Mk 400 RB had not yet been selected. As to the ULMS

[161]"Nuclear Technology and Analysis Report (U)," Headquarters Field Command Defense Nuclear Agency, Kirtland Air Force Base, New Mexico 87115 (SRD) (December 1, 1971), pp. 65–66, A99-019, 192-9.

[162]K. F. Famularo, TD-4 to Distribution, Subject: "ULMS-1 Meeting with Kaman Sciences Corporation (KSC) at LASL on December 7, 1971," TD-4-71-367 (SRD) (December 9, 1971), 7 pp., A99-019, 214-15.

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[164]F. B. Baker, F. W. Kramer, B. E. Hoverson, and R. B. Olwin to H. P. Deinken, W-9, Subject: "Trip Report C-4/Mk 400 (Formerly ULMS-1) Meeting at LMSC December 8, 1971," W-9-1285 (SRD) (December 16, 1971), 5 pp., A99-019, 307-8.

[165]C. H. Mauney to Naval Plant Representative Office, Sandia document RS 1500/1784 (SRD) (February 25, 1972), 2 pp., B11, Drawer 56, Folder 1 of 4.

[166]Vincent C. Vespe, Director Weapons Development Division to Distribution (SRD) (December 1, 1971), 1 p., A99-019, 214-15.

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In a letter dated February 1, 1972, to Foster, Edward B. Giller, Assistant General Manager for Military Application, stated, "The Atomic Energy Commission is pleased to cooperate with the Department of Defense and participate in a Phase 2 weapon feasibility study for the purpose of developing the new ULMS I ballistic reentry vehicle warhead as requested by your letter of January 12, 1972." However, Giller did not feel that Foster had allowed adequate time for the completion of a Phase 2 report. Giller noted, "Accordingly, it is suggested that a Phase 2 feasibility study be conducted as soon as the draft MC's and STS can be made available to the AEC and that a completion date of July 1, 1972, be set." He also commented, "In order to conduct the pre-Phase 3 meetings, I recommend the designation 'mini-POG' for the group."[171]

In addition to his letter to Foster, Giller also sent out a memo on February 1, 1972, to the manager of the Albuquerque Operations Office and to the various laboratory directors. He noted that Foster had been informed that the Phase 2 feasibility study could not be completed as soon as Foster had wanted, Giller estimated that the most realistic date was July 1, 1972. Giller instructed that work should continue on the Impact and Capability Study (I&C Study). Giller stated, "The ALO portion of the I&C Study should be completed before ALO signature release on the final Phase 2 study. Giller then requested, "Please keep me advised of your progress and of key meeting dates."[172]

Despite the fact that Giller felt that the Foster-proposed Phase 2 date was unreasonable, nevertheless a quick response from the Laboratories to provide the necessary information to those preparing the Phase 2 would be required in order to meet the Giller proposed summer deadline. Realizing that Los Alamos was going to have to provide information for the Impact and Capability (I&C) Study and for a draft Phase 2 report, Gillespie sent a memo dated February 7, 1972, to MacDougall outlining the requirements. Gillespie noted that the LASL warhead data needed to be at Lockheed by February 14. The information for the Phase 2 package needed to go to SSPO by February 28. The input for the I&C Study also needed to go to ALO by February 28. In order to respond in this limited time, the Los Alamos group was going to do one basic document to serve for both the Phase 2 input and the I&C input. But Gillespie noted that the Los Alamos group was still several days away from having "even a rough first draft." However, Gillespie provided MacDougall with a proposed outline of the report. In turn, MacDougall sent a memo dated February 8, 1972, to the LASL management with the Gillespie memo attached and urged those responsible to meet the schedule. MacDougall noted, "Should problems develop which threaten to slip the time scale shown in the attached memo, I would like them brought to my immediate attention."[173]

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[171]Edward B. Giller to Honorable John S. Foster, Jr. (SRD) (February 1, 1972), 2 pp., Appendix B (SRD) of "Joint AEC/DOD Mk 400 Phase 2 Feasibility Study Report," B11, Drawer 56, Folder 1 of 4.
[172]Edward B. Giller to H. C. Donnelly, Manager, Albuquerque Operations et. al., Subject: "DOD Request for a Phase 2 Study of the ULMS I Ballistic Reentry Vehicle Warhead," (SRD) (February 1, 1972), 2 pp., B11, Drawer 56, Folder 3 of 4.
[173]D. P. MacDougall to Distribution, Subject: "W-9-1344 (attached)," (SRD) (February 8, 1972), 1 p. and attachment, B11, Drawer 56, Folder 3 of 4.

In an attachment to a cover memo dated February 15, 1972, Gillespie sent the various people in the LASL administration the rough draft of the proposed Los Alamos input to the Mk 400 Phase 2 submission. He wanted comments back by February 17. Gillespie wrote, "I am available day or night for discussion." The draft indicated that the LASL base-line proposals were environmentally sealed/integrated packages. This type of engineering resulted in the device having several advantages over the current Mk 3 (W68) warhead. Because the LASL/SLA proposed warhead/arming and firing systems were constructed as a unit, there was much more flexibility in terms of both the final assembly of the reentry body and in any required repairs. Sealing the warhead meant simplification in the fabrication assembly and certification. The design allowed field exchange of the reservoir.[174] [Author's note: One of the reasons for Los Alamos pushing this aspect of their designs was the fact that the Navy was not happy with the difficulty of making limited life exchanges or repairs in the W68.]

During the WWG meeting held on February 16, 1972, MacDougall reported that the Laboratory was currently "deeply involved in trying to prepare the Phase 2 input for the MK 400 warhead for ULMS." The meeting minutes report, "He asked that, since this is the most likely chance we have at a new Phase 3, every effort be devoted to helping Gillespie collect the information he needs for the [Phase 2] package."[175] [Author's note: From this directive by MacDougall, it is clear that the upper management at Los Alamos had decided to fight hard for the Mk 400 warhead assignment.]

On February 17, 1972, Olwin sent out a memo that outlined what the LASL groups were doing in terms of input for the vulnerability requirements. He noted that there was to be a meeting in Washington on March 2 to discuss the hostile environments' section of the STS (stockpile-to-target sequence) document. Olwin noted that Ken Famularo had already met with several of the staff at Kaman Science. George Spillman had also provided relevant information.[176]

On February 23, Gillespie sent out to the Los Alamos group (through W-Division leader R. G. Shreffler) the final draft of the Los Alamos Mk 400, Phase 2 input. Gillespie stated, "Assuming there are no major changes we can work over the weekend and get it on a plane Monday afternoon."[177]

In a February 25 letter to the Navy, C. H. Mauney of the Systems Development Department of Sandia noted that the LASL/SLA warhead proposals would be contained in the Phase 2 input submitted to SSPO on February 28, 1972. These proposals would be similar to those already submitted to LMSC. Mauney reported, "Since the warhead and RB are a tightly integrated system, we have worked closely with LMSC to arrive at the best possible warhead design."[178]

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[174] C. M. Gillespie, W-9 to Distribution, Subject: "Mk 400 Phase 2 Input" (SRD) (February 15, 1972), 1 p. and enclosure, B11, Drawer 56, Folder 3 of 4.
[175] "Weapons Working Group Minutes of the 237th Meeting," WWG-237 (SRD) (February 16, 1972), p. 8.
[176] R. B. Olwin, W-10 to Distribution, Subject: "Mk 400 Vulnerability Subcommittee Meeting," W-10-72-60 (SRD) (February 17, 1972), 2 pp., B11, Drawer 56, Folder 3 of 4.
[177] C. M. Gillespie, W-9 to Distribution, Subject: "Mk-400 Phase 2 Input," (SRD) (February 23, 1972), 1 p. and enclosure, B11, Drawer 56, Folder 3 of 4.
[178] C. H. Mauney to Naval Plant Representative Office, Subject: "LASL/SLA Proposals for the C4/Mk 400 Phase 2 Study," RS 1500/1784 (SRD) (February 25, 1972), 2 pp., B11, Drawer 56, Folder 1 of 4.

In a February 28, 1972, memo, MacDougall reported that Giller was anticipating that a Phase 3 request for a ULMS might be initiated in the FY 1972–1974 time period. At the same time, Giller did not want any work that did not directly support either present or anticipated future weaponization requirements to receive a high priority.[179]

The W-9 report dated February 28, 1972, titled "LASL and SLA Input to the ULMS MK-400 Ballistic Reentry Body Phase 2 Feasibility Study" was released as W-9-1350. As previously noted, this report served as the input from Sandia and Los Alamos both on the Phase 2 and the Impact and Capabilities studies,

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This document was sent to Commander R. J. Stinner at the Strategic Systems Projects Office. In his cover letter to Stinner, Gillespie noted, "Signature of the final Phase 2 Feasibility Study is dependent upon review and approval of the complete Phase 2 Study, including the RB synthesis work by LMSC." Additional information on the LASL study is available in the cited reference.[181]

On February 29, 1972, Giller sent AEC Chairman Schlesinger and the other four commissioners, a summary of the ULMS-1 program. Giller reported that the Secretary of Defense had, on September 14, 1971, directed the Navy to develop a new submarine for deployment in the early 1980s. At the same time, a new missile system was to be developed that was also to be compatible with the present Poseidon-type submarines. On December 28, 1971, the Secretary of Defense had directed that the effort be aimed at delivering the first ULMS submarine in December 1977. The Giller memo then outlined the program in some detail. It is interesting to note that Giller indicated that the missile would require a new reentry body/warhead combination, primarily because the current Mk 3 RB was not designed for the more severe flight environment that the new RB would be subjected to. Other design objectives were a lighter/smaller RB, higher warhead yield, and improved hardening. Giller discussed the nuclear material implications.

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Giller also reported on what the various Navy groups were doing or had an interest in. He noted that Rear Admiral Harvey Lyons, the ULMS program manager, was concentrating on hull-design technology.

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Giller reported, "They are apparently willing to pay some penalty in payload weight to achieve the higher yield."[182]

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[179]D. P. MacDougall to Distribution, Subject: "Program Planning," ADW-204 (SRD) (February 28, 1972), 3 pp., B11, Drawer 49, Folder 1 of 5.

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[181]C. M. Gillespie to Cdr. R. J. Stinner, Subject: "Transmittal of LASL/SLA Input to the Mk-400 Phase 2 Feasibility Study, W-9-1350" (SRD) (February 28, 1972), 1 p. and enclosure W-9-1350, B11, Drawer 56, Folder 3 of 4.

[182]Edward B. Giller to Chairman Schlesinger, Commissioner Ramey, Commissioner Johnson, Commissioner Larson, Commissioner Doeb, Subject: "Undersea Long-Range Missile System (ULMS) and ULMS-I Missile," (SRD) (February 29, 1972), 10 pp., B11, Drawer 56, Folder 3 of 4.

On March 8, Gillespie, in a letter to Vespe at the Albuquerque Operations Office, enclosed two drawings of the LASL design proposed for the I&C study.

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Vespe, at the Albuquerque Operations Office, with a cover memo dated March 31, 1972, sent the weapon laboratories and the plants the AEC input for the "AEC weapon's production system for the Mk 400 RB I&C Study."[184]

In a W-Division review report dated March 31, 1972, it was indicated that the development of small primaries was an integral and important part of the total effort for strategic offensive systems. At the same time it was necessary, in order to achieve maximum range, to highly integrate the reentry vehicle and the warhead. By doing this integration, it was anticipated that a 5% to 10% improvement in yield-to-weight and yield-to-volume ratios would be possible.

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In a memo to Shreffler in W-DO, dated May 2, 1972, R. B. Olwin from W-10 noted that there was a gloomy outlook on the Mk 400 program that had been displayed by the staff and management at Los Alamos. In order to see if this was indeed warranted, Olwin then discussed the Mk 400 program at that time

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In all cases, the Livermore proposals did not weigh as much

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Olwin also noted in his memo, "The Navy was quite adamant with regard to the AEC supplying a sealed warhead package rather than allowing the seal to be a part of the RB as was done on the MK-3. Navy sensitivity to the problems brought about by the MK-3 was behind this directive. LASL responded by supplying a neatly sealed package whereas LLL ignored the request and proceeded to seal at the RB substructure." Olwin reported that the LMSC engineers considered the LLL/SLL proposed seal design to be a high risk.[186] [Author's note: In this memo, we see some aspects of what would become the LASL defense against LLL. The previous problems with the warheads supplied to the Navy by LLL would be carefully noted. The problems with replacing limited-life components would be outlined. It would be indicated that two types of warheads, one from each Laboratory, were needed; one as a backup in case there were problems

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[184]Vincent C. Vespe to Those on Attached List, Subject: "Mk 400 RB I&C Study," (SRD) (March 31, 1972), 4 pp. and enclosure, B11, Drawer 56, Folder 3 of 4.

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[186]R. B. Olwin, W-10 to R. G. Shreffler, W-DO, Subject: "MK 400/500," W-10-72-169 (SRD) (May 2, 1972), 5 pp., B11, Drawer 56, Folder 1 of 4.

with either one. (b)(3)

The LASL management would try to impress on the Navy the LASL desire to work with the Navy and its contractors and to respond to all their concerns.]

In a May 9, 1972, letter to V. C. Vespe at the Albuquerque Operations Office, Gillespie reported that to meet the Mk 400 development program there was a need for six NTS tests. These tests could not yet be formalized because the final yield requirement for the Mk 400 had not yet been specified.[187] (b)(3)

In the spring of 1972, it was announced that there had been a change to a rounded aft end in the reentry body. This change would reduce the radar cross section. But the change also meant that the earlier higher-yield designs were also affected—their dimensions would need modification. The Los Alamos group indicated their changes in the Phase 2 input in a TWX dated May 16, 1972.[188]

To provide data on cost for the Impact and Capabilities report, a TWX was sent out on May 15, 1972. This TWX requested cost estimates for the NTS tests that would be required to complete each design for the stockpile should that design be chosen for the Phase 3 program. As would be expected, the W68 proposal required the fewest number of tests. At the same time, the LASL group appears to have been very optimistic as they listed in most cases a requirement of only three tests.[189] These were apparently the number of required full-scale tests because a slightly earlier memo had reported that LASL would require a one-point safety test, two primary tests, and three full-yield tests in order to develop the Mk 400.[190] [Author's note: This information on the number of tests reported as required indicates that the LASL design team must have felt under a great deal of pressure to limit the number of tests, once the Phase 3 was given to LASL.]

During the May 17, 1972, meeting of the WWG, Canada described the LLL test program for FY73.

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[187]C. M. Gillespie to Mr. V. C. Vespe, W-9-1423 (SRD) (May 9, 1972), 2 pp., B11, Drawer 56, Folder 1 of 4.

[188]C. M. Gillespie thru D. P. MacDougall, University of California Los Alamos Scientific Laboratory, Los Alamos, N.M., to RULSSAA/Cdr. R. Stinner, Strategic Sys. Projects, Dept. of Navy, Washington D.C. et. al., W-9-1430 (SRD) (May 16, 1972), 2 pp., B11, Drawer 56, Folder 1 of 4.

[189]USAEC Vincent C. Vespe, Dir. Wpns. Dev. Div., Albuquerque, N.M. to BP3/USAEC R. W. Taft, NVO et. al. (SRD) (May 15, 1972), 6 pp., B11, Drawer 56, Folder 1 of 4.

[190]C. M. Gillespie to Mr. V. C. Vespe (SRD) (May 9, 1972), 2 pp., B11, Drawer 56, Folder 1 of 4.

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On June 5, 1972, David B. Anthony, Assistant Manager for Plans & Budgets at the Albuquerque Operations Office, wrote the Director, Strategic Systems Project Office in Washington. Anthony reported that the AEC was presently engaged in an Impact and Capability Study (I&C) to estimate the cost of refitting the Poseidon C3 boats with Mk 400 RBs. The AEC was also considering the possible addition of the Mk 400 RBs for the new Tridents boats. He noted that the AEC had a reactor products' availability problem in the Mk 400 program.[192]

On June 16, 1972, H. N. Meyer from the Albuquerque Operations Office sent out the first draft of the Report of the Mk 400 I&C (Impact and Capabilities) Study for the Mk 400. A meeting was to be held in Albuquerque on June 22 to receive any final comments.[193]

On June 23, 1972, C. H. Mauney from Sandia distributed the draft titled.

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The second meeting of the Mk 400 mini-POM (Project Officers' Meeting) group was held in Washington on June 28, 1972. The Navy's representative from SSPO announced that the ULMS program would henceforth be known as the Trident program. The word Trident would be used to describe that system and the various portions of the system. Then the representative made an interesting and important statement. The Trident C4 missile system was designed to be fitted into existing SSBN's (nuclear-powered submarine, ballistic-missile-bearing) as well as into the Trident submarine. The Trident II D-5 would be the name given to the follow-on missile system to be designed particularly for the Trident submarine. Existing SSBN's when back-fitted with the Trident I missile would not be classed as Trident submarines but would remain Trident I back-fit SSBN's. It was announced that the Phase 2 report for the Mk 400 had been approved, signed by all participants, and published. [Author's note: This appears to have been the final draft of the Phase 2 report.] It was expected that this document would be issued in the near future. It was also reported that the entire STS document was in the final stages of preparation.[195]

The Albuquerque Operations Office draft of their Mk 400 I&C study, circulated in the summer of 1972, carries the date of July 1, 1972. This draft states that the AEC presently had the capability and the capacity, with modest additions, to support the Poseidon refit with an IOC of December 1977 and a Trident outfit with an IOC of October 1978. In this study, it was assumed that a Phase 3 development authorization would be received by the summer of 1972. It is interesting to note that the draft report states, "The advisability of additional production of W68 nuclear systems in the late 1970's and early 1980's is questionable." The report states, "Availability of special materials was assumed to be adequate as necessary to produce any of the designs with normal working inventories as weapons grade materials, fully compatible with

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[192]David B. Anthony to Director, Strategic Systems Project Office (SRD) (June 5, 1972), p. 1, B11, Drawer 56, Folder 1 of 4.

[193]H. N. Meyer to C. M. Gillespie, W-9 LASL et. al., Subject: "Mk 400 I&C Study Report," (SRD) (June 16, 1972), 1 p., and enclosure, B11, Drawer 56, Folder 1 of 4.

(b)(3)

[195]"Nuclear Technology and Analysis Report (U)," Field Command, Defense Nuclear Agency Technology and Analysis Directorate, Kirtland Air Force Base, New Mexico 87115 report FC/08720008 (SRD) July 21, 1972), p. 29, B11, Drawer 57, Folder 1 of 2.

fabrication facilities." (b)(3)

Additional information is available in the cited reference.[196]

(b)(3)

The final draft of the Phase 2 feasibility study report was also released in the summer of 1972. (b)(3) In the Los Alamos files the draft study report carries a date, made in pencil, of July 1, 1972. The cover sheet for the document carries a date of June 26, 1972. As previously noted, during the second meeting of the Mk 400 mini-POM group held on June 28, 1972, it had been announced that the Phase 2 report had been approved.]

(b)(3)

The final yield of the new warhead had not yet been specified.

(b)(3)

In the

[196]"Report of Impact and Capabilities Study for the Mk 400 Reentry Body for Poseidon C-4 and Trident (Previously ULMS)," Draft, AEC Albuquerque Operations Office report I&C No. 5-72 (SRD) (July 1, 1972), 20 pp., B11, Drawer 56, Folder 1 of 4. Also in B11, Drawer 56, Folder 3 of 4.

(b)(3)

sealed systems, the complete nuclear device/AF&F assembly was designed to withstand repeated launch-tube pressurization to 200 psi. In summary, the LASL/SLA group noted, "Our extensive work with LMSC prior to and during the Phase 2 effort has established that all the designs are compatible with the C4/MK400 system as presently defined. We have seriously addressed the problem of integrating the warhead into the RB and our proposals reflect a realistic approach to this problem. We believe it offers many advantages to the Navy over the MK3 approach."[198]

In the Los Alamos files, despite the fact that it is dated July 1, 1972, the final "Joint AEC/DOD Mk400 Phase 2 Feasibility Study Report" carries on its front sheet a handwritten date of September 12, 1972. The cover letter for sending the report was written by Levering Smith at the Strategic Systems Project Office in Washington; this letter has a date of September 5, 1972. In this final study, the Los Alamos group indicated that they felt they could develop the device three and a half years after the award of the Phase 3. They foresaw no difficult development problems.[199]

(b)(3)

Paul Vander Maat from TD-2 and K. F. Famularo from TD-4 on July 24, 1972, sent an extremely interesting memo to T. A. Sandford. [Author's note: This was probably sent in preparation for Sandford's forthcoming August trip to Washington.]

(b)(3)

[198] "Final Draft, Joint AEC/DOD Mk400 Phase 2 Feasibility Study Report," Strategic Systems Project Office, Department of the Navy, Washington, D.C., 20390 document K-24304 (SRD) (not available), 88 pp. with Appendix A and B, B11, Drawer 56, Folder 1 of 4.
[199] Director, Strategic Systems Projects to Chief of Naval Operations (OP-21), Subject: "Joint AEC/DOD Trident Mk 400 Re-entry Body Feasibility Study," (SRD) (September 5, 1972), 1 p. and enclosures, B11, Drawer 57, Folder 2 of 2.

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16-inch base diameter in the RB. This is the base diameter used in the design of the W76.] Near the end of his trip report, Sandford included several pieces of interesting "gossip." He reported, "At DDR&E we talked to John J. Brett who seemed to react favorably to our new, higher yield proposals. At the SPO we briefed Cdr. Stinner, Mark Messerole, and Hal McMasters. They seemed relieved and/or amused that our WHs now were competitive with LLL's WHs." In addition, Sandford reported, "At DMA we briefed General Camm, Tom Clark, Col. Haidler, and several of their staff members. The briefing went very well with several pertinent questions being asked." Furthermore, Sanford reported, "The MK-400 I&C study indeed was stuck in the AEC.

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Pending resolution of this problem, the Phase 3 request cannot be sent to DMA." It was also noted in the trip report that the question of the requirements for special nuclear material had been discussed by Tom Clark. The trip report states, "The only concrete message gleaned from Clark's talk was that one or two reactor restarts at Savannah River are feasible but the AEC does not want to restart any of the Richland reactors."[203]

Despite this report from Hoyt and Sanford of the delay in the I&C study, on August 17, the AEC proposed to send the AEC Impact and Capability study to Foster at the Defense Research and Engineering, Department of Defense. As to the reactor question, the proposed cover letter for the study noted, "In addition, we believe that, while restart of up to four reactors is theoretically possible, in light of decisions which have been made in the past the restart of the two standby reactors at Savannah River would be difficult enough to achieve; the restart of additional reactors at Richland might pose intractable problems, particularly in view of current environmental concerns." The letter added, "Certain adjustments to the assumed Mk 400 delivery schedules and to the assumed base stockpile might possibly reduce the number of reactor restarts required." The letter ended by stating, "In order to meet the desired IOC date of December 1977 it will be necessary for us to receive a Phase 3 decision by the end of August so that the AEC can arrange for the necessary capital funding."[204]

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He included attachments of the vufoils that had been used in the August 7 briefing given to Assistant DDR&E Director John J. Brett.[205]

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[203]T. A. Sandford to D. P. MacDougall, ADW, Subject: "Mk-400 and High Yield Bomb Briefings in Washington (U)," ADWP-1-72-19 (SRD) (August 17, 1972), 7 pp., B11, Drawer 56, Folder 3 of 4.
[204]Thomas R. Clark to J. A. Hornbeck, President, Sandia Laboratories et. al., Subject: "Mk 400 I&C Study," (SRD) (August 21, 1972), 1 p., and two attachments, B11, Drawer 56, Folder 3 of 4.
[205]T. A. Sandford to Dr. John S. Foster, Jr., Subject: "LASL/SLA MK-400 Briefing (U)," ADWP-1-72-20 (SRD) (August 21, 1972), 8 pp., B11, Drawer 56, Folder 3 of 4.

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Hoyt noted that the members of the WPRC had recommended that the TD proposal be accepted.[206]

On August 28, 1972, Sandford wrote Camm to provide him the information in writing that had been provided during the August 8 briefing. He also included hard copies of the slides that had been used in the briefing.

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These new designs allow a 10 to 15 pound RB weight saving, meaning that for a fixed payload yield, greater range could be realized or, for a fixed range, more yield could be delivered to the target."

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This test will incorporate the 'new' technology cited in our Mk 400 study." Sandford assured Camm that the costs of all the LASL warhead proposals were covered in the current Mk 400 I&C Study.[207]

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8. Where is the Phase 3?

During the WLPC meeting held on September 11, 1972, Hoyt reported that a letter had been prepared by the Navy requesting that the Mk 400 program be put into Phase 3. Hoyt noted that he was hopeful that LASL would receive the Phase 3 assignment.[209]

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[207] T. A. Sandford to Major General Frank A. Camm, Asst. Gen'l Manager for Military Application, Subject: "LASL/SLA MK-400 Briefing (U)," ADWP-1-72-24 (SRD) (August 28, 1972), 12 pp., B11, Drawer 56, Folder 3 of 4.

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[209] D. P. MacDougall to WLPC Members, Subject: "WLPC Meeting No. 99, September 11, 1972," (SRD) (September 12, 1972), 2 pp., B11, Drawer 53, Folder 1 of 2.

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Additional information is available in the cited reference.[211]

The W-Division program report dated September 22, 1972, stated that there had been continued LASL coordination with all the Mk 400 agencies in terms of design studies, flight and ground testing, and simulation test planning. This effort should permit a smooth transition when the Phase 3 award was made. Analytical studies were currently in progress to investigate areas where the LASL group could assist LMSC in obtaining a minimum weight, integrated reentry system.[212]

On September 25, 1972, John Foster wrote AEC Chairman, James R. Schlesinger, that the Navy had not yet forwarded their recommendations on the Phase 2 study. Foster therefore anticipated that a specific selection of a Phase 3 design would not be decided for several months. It appeared that the Mk 400 IOC might be delayed until somewhere around December 1978. However, despite all this uncertainty in the program, Foster wrote, "I am therefore suggesting that the AEC take the necessary planning actions consistent with an IOC for the Mk 400 as early as December 1977. A specific Phase 3 request will be forwarded as soon the DOD review of the Phase 2 study is completed."[213]

The next meeting of the Mark 400 Mini-POM was held at Lockheed on September 27–28, 1972. Representing LASL were K. F. Famularo (TD-4), J. C. Fuller (WX-6), C. M. Gillespie (ADWP-1), F. W. Kramer, (WX-3), and T. A. Sandford, (ADWP-1). During the meeting, it was announced that Secretary Rush had issued a program decision directive that delayed the Mark 400 IOC by 10 months to October 1978. Thus, the Mk 400 and Trident submarine would have the same IOC dates. The directive delayed the Poseidon backfit until 1979 or 1980. This directive implied that the first C4 missiles would go on the Trident submarines instead of being backfitted into the Poseidon. The Mk 500 was canceled. The Navy's Commander Stinner reported that the Phase 3 letter was being reviewed by the Navy. In lieu of an immediate Phase 3 request, Stinner hoped that a letter dated September 25, 1972, from Foster to Camm (Major General Frank A. Camm, Assistant General Manager for Military Application) that guaranteed a Phase 3 go-ahead, would be used to designate a design laboratory.

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The Navy's BuMed manual requirements for radiation safety would have to be met by the Mk 400.

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Representatives from Lockheed then reported on their work.

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D. Aspinwall from Lockheed noted that, to eliminate range

[211]C. A. Anderson and F. W. Kramer to Jesse Aragon, Subject: "Meeting – Mark 400 Packaging Design Exercises at LASL and SLA (U)," WX-3-72-35 (SRD) (October 3, 1972), 2 pp., B11, Drawer 56, Folder 2 of 4.

[212]"W Division Program Reporting System," WX-72-6 (SRD) (September 22, 1972), pp. 138–140, B11, Drawer 56, Folder 4 of 4.

[213]USAEC William B. Haidler, Wash., D.C. to AN3 USAEC H. C. Donnelly, Albuq., N.M. et. al. (SRD) (November 10, 1972), 6 pp., B11, Drawer 56, Folder 1 of 4.

reductions associated with nose radii greater than optimum, they were considering a self-deploying aerospike on the nose fairing of the C4 missile.

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The flight test program was also discussed. The AF&F sequence of the Mk 400 was also reviewed. There were several presentations made during the meeting on the possible types of overcoats that might be used to reduce vulnerability.[214]

The quarterly progress report from the Laboratory for the period ending September 30, 1972, noted that for the Mk 400 there had not been a Phase 1 program. Phase 2 had been informally started in November 1971; however, the formal direction from DMA to participate in the Phase 2 had not been received until February 3, 1972. The LASL Phase 2 data package had been submitted on February 28, 1972. Although the final Phase 2-study report had been dated July 1, 1972, the report had not been formally distributed by SSPO until September 1972. In August 1972, the LASL groups had presented to SSPO, DDR&E, and DMA representatives the new design improvements that had been made. In turn, new reentry-body weights for the new warhead proposals had been developed.[215]

The Trident system was discussed at length during the October 5, 1972, meeting of the Theoretical Weapons Group (TWG). Gillespie stated that the purpose of the Fleet Ballistic Missile System was to provide deterrence through an invulnerable force capable of inflicting unacceptable damage to the Soviet urban/industrial complex. Gillespie noted that by treaty the United States was limited to 44 submarines. As of October 1972, the U.S. had 10 Polaris submarines that carried the A3 missile. (b)(3) There were 31 Poseidon submarines that carried the C3 missile (b)(3) The new Trident would carry the C4 missile (b)(3) Trident had an IOC of 1978. It was twice as large as the Poseidon boat and could carry the larger D5 missile.

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Gillespie also noted the importance of minimum weight in terms of maximum range. Gillespie then discussed, assuming that LASL was assigned the Phase 3 in January 1973, the future test program

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Several additional tests would be necessary before a final weaponized design was achieved. The minutes of the meeting state, "In closing, Gillespie outlined the reasons for supporting LASL as the recipient of the MK 400 Phase 3 in terms of past experience, the present LASL program and the availability of program support

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[214]F. W. Kramer, K. F. Famularo, J. C. Fuller, C. M. Gillespie and T. A. Sandford to Distribution, Subject: "Mark 400 Mini-POM, September 27-28, 1972 (U)," ADWP-1-72-52 (SRD) (October 12, 1972), 4 pp., B11, Drawer 56, Folder 1 of 4.

[215]Leslie M. Redman and Cecil C. Carnes, Jr., "LASL Weapons Quarterly (U), for the Period Ending September 30, 1972," Los Alamos Scientific Laboratory report LA-5130-PR (SRD) (January 1972), p. 68.

In a letter dated October 31, 1972, R. B. Olwin from Los Alamos wrote to the Navy Strategic Systems Project Office at Lockheed. The purpose of the letter was to indicate that the Los Alamos team had made significant improvements in the Mk 400 since the Phase 2 input dated February 29, 1972.

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In papers dated November 2, 1972, and titled, "MK-400 X-Ray Hardening Weight Penalty Calculations" and "Warhead X-Ray Hardening," R. S. Dingus discussed the x-ray hardening considerations for the Mk 400.[221]

On November 8, 1972, Olwin wrote a letter to inform the groups working on the Mk 4 of the need for drawings describing the basic WH layout of the Mk 400.

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In a phone call to Chuck Gilbert at DMA, Livermore's McDonald objected to this proposal. However, the Navy representatives called a meeting to be held at Lockheed to discuss how to respond to the Camm proposal. A preliminary meeting of the AEC representatives was held at Livermore on November 15

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[221]R. S. Dingus, "Warhead X-Ray Hardening," WX-6-72-114 (SRD) (November 2, 1972), 9 pp. R. S. Dingus, "Mk –400 X-Ray Hardening Weight Penalty Calculations," WX-6-72-115 (SRD) (November 2, 1972), 9 pp., B11, Drawer 56, Folder 2 of 4.

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Another meeting was held near the end of November between LASL and LMSC representatives.

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The trip report from the Los Alamos attendees included the following gossip, "Both with Howard [Howard Trudeau, Manager, Reentry Systems] and all other LMSC personnel I have noticed a definite change in their attitude from polite tolerance to an anticipation of working together on the Mk 400."

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This is an extremely sore point with the LMSC working troops and they are convinced that ALO has been brainwashed by Jim Wright, SLL." Additional information on detailed designs and studies discussed by LASL and LMSC representatives at this meeting is available in the cited reference.[224]

A TWX was sent out on November 28, 1972, from Vespe in the Albuquerque Operations Office.

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The minutes of the December 4, 1972, WLPC meeting have an interesting bit of information. The minutes report that on the Friday before the WLPC meeting, Hoyt had presented to General Camm in Washington "…the case for assigning the Mark 400 warhead Phase 3 job to LASL." LASL representatives were optimistic that the "assignment of this warhead to us is in the bag."[226]

On December 5, 1972, F. W. Kramer and L. A. Ney from WX-3 and representatives from Sandia met with the LMSC representatives to discuss possible Mk 400 mounting arrangements.

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Indeed, the LMSC group might propose it as the base line underlay at the December meeting of the vulnerability subcommittee.[227]

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[226]D. P. MacDougall to Members, WLPC, Subject: "WLPC Meeting No. 105, December 4, 1972," ADW-323 (SRD) (December 5, 1972), 3 pp., B11, Drawer 53, Folder 1 of 2.

[227]T. A. Sandford, ADWP-1 to Distribution, Subject: "Trip Report – Mk 400 Discussions at LMSC (U)," ADWP-1-72-93 (SRD) (December 19, 1972), 2 pp., B11, Drawer 56, Folder 3 of 4.

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Liaison Committee for review and transmittal to the AEC. An IOC of October 1978 was desired.[254]

During the April 27 meeting of the WLPC, it was announced that the Mk 400 and its warhead had been put into Phase 3. The warhead development had been assigned to LASL/SLA. [Author's note: The Camm TWX, dated April 27, 1973, assigning the Mk 400 to LASL is discussed in the following paragraph.] Olwin, who had been in Hoyt's organization, would transfer to the Weapon Program Office where he would be the manager for the Mk 400 warhead program. The requirements for the warhead had been spelled out in a letter from Foster to the AEC Chairman. The desired IOC was October 1978. After these announcements, Agnew instructed that an immediate review of the test program take place in order to make sure that it was consistent with this potential task "that has now become a reality." It was noted that the reason cited by General Camm for assigning this task to LASL was that LLL had developed all of the strategic missile warheads for the past ten years, and to maintain the validity of the assertion that the two Laboratories were competitive across the board, LASL should have one of these jobs. MacDougall remarked in his minutes of the meeting that it was obvious that the Laboratory must do its absolute best to make the program a success.[255]

During the May 3, 1973, WPRC meeting, it was again announced that LASL had received a Phase 3 request to develop the Mk 400 warhead. The letter from Foster and a TWX from General Camm was included as an appendix in the meeting minutes. The TWX from General Camm dated April 27, 1973, assigned the project to Los Alamos. The Camm TWX stated, "After carefully reviewing factors relevant to Mk 400 Phase III development engineering, I have concluded assignment to LASL would contribute most to overall viability of the two-laboratory competitive concept. This concept has proven its value many times over in meeting National Defense needs in imaginative ways which led to dramatic improvements in defense capabilities while at the same time reducing greatly overall system costs for achieving specific Military effects." But Camm also noted, "Selection of LASL rather than LLL should in no way be construed as a reflection on LLL capabilities and contributions. On the contrary LLL contributions have essentially monopolized strategic RV warheads for the last decade to the extent that the Mk 400 is an appropriate opportunity for LASL to design one." Camm ended his TWX by stating, "Accordingly, I am assigning the Mk 400 to LASL."[256]

In a May 3 letter to Captain Wayne L. Beech at the Division of Military Application, Hoyt outlined the Laboratory's plans for the Mk 400 program. He reported that suitable designs for the primary and secondary were being developed.[257]

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[254]USAEC William B. Haidler, Wash, D.C. to AN3 USAEC, H. C. Donnelly, Albuquerque, N. M. et. al. (SRD) (April 24, 1973), 5 pp., B11, Drawer 115, Folder 1 of 4.

[255]D. P. MacDougall to Members, WLPC, Subject: "WLPC Meeting No. 111, April 27, 1973," ADW-370 (SRD) (April 30, 1973), p. 1, B11, Drawer 111, Folder 2 of 3.

[256]Roger B. Perkins to Distribution, Subject: "Minutes of the 3 May 1973 WPRC Meeting," AP-14 (SRD) (May 8, 1973), 2 pp. and two enclosures, B11, Drawer 111, Folder 2 of 3.

[257]Harry C. Hoyt to Captain Wayne L. Beech, ADWP (SRD) (May 3, 1973), 1 p. and enclosure ADWP-73-25, p. 12, B11, Drawer 110, Folder 2 of 4.

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The second quarter report from the Laboratory for 1973 noted that the Mk 400 was the reentry body for the C4 Trident missile; it was being designed for use on the new Trident submarine

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. (~~Phase 3 development of the W76~~ WH for the Mk 4 RB was ~~awarded to LASL and SLA on A~~pril 27, 1973.)"[264]

11. Significance

It had been a long and at times bitter fight. But the laboratory at Los Alamos had won the long desired strategic warhead assignment. However, the laboratory staff was now under extreme pressure to develop and design a warhead that would (1) meet the yield requirement, (2) meet the size and weight requirements, (3) achieve the vulnerability and safety requirements, and (4) at the same time satisfy the minimum number of NTS development tests, the strict time restraints, as well as the budget limits that had been placed on weapon development.

It was never envisioned that the in the year 2003 planning would be in progress to retain the W76 in the U.S. stockpile.

C. Harold Agnew

1. Proponent

While the entire staff at Los Alamos worked hard to obtain the Phase 3 for the Mk 400, one of the chief proponents for this award was Harold Agnew. (From the information given in Chapter I, the reader will recall that Agnew became Laboratory Director in 1970.) Agnew felt that there were many reasons why the award should go to Los Alamos

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[264] Leslie M. Redman, "~~LASL~~ Weapons Quarterly (U), for the Period Ending June 30, 1973," Los Alamos Scientific Laboratory report LA-5401-PR (SRD) (September 1973), p. 58.

Agnew voiced his viewpoint in numerous letters and TWXs to Washington. Considering the fact that he was on many panels and committees that included military personnel, Agnew must have also presented his viewpoint informally at appropriate moments.

The Agnew concerns will be discussed in greater detail in the following sections.

2. Reliability

The folklore among the "old timers" at Los Alamos is that it was Agnew that pressed for the testing of Livermore's mechanical safing systems employed in some of their weapons. The objective of these tests was to determine if the safing system could actually be withdrawn in order to prepare the warhead for activation. The reader of this author's previous document, LA-13755-H (SRD), will recall that when these tests were undertaken not all the safing systems worked as required. The question then became "How many duds in the system?" Agnew apparently noted this problem at opportune moments. For example in a November 29, 1966, letter to General Earle G. Wheeler, Chairman, Joint Chiefs of Staff, Agnew wrote, "I have been worrying for several years about the actual implementation of what we commonly refer to as our assured destruction capability. Recently a great deal of effort has been directed toward reducing the vulnerability of the forces we have for this role against possible enemy action throughout all stages of their stockpile-to-target sequence. However, I wonder if we have protected ourselves to the degree we might have against basic system component design failures which to some degree or another always turn up. The most recent example is the MK-47 Polaris problem." In discussing the prospect for the Mk 3 and Mk 18 carrying the same warhead, Agnew wrote, "If a defect turned up in the warhead some years from now the complete force could be in trouble." He went on to say, "If I were in a position to make such decisions I would suggest that in a missile system such as Poseidon or the new Minuteman that there be a mix of basic missiles, perhaps a different mod for every one or two hundred missiles and a mix of RV's with warheads. I would have a warhead mix such that no more than a quarter of the missile warheads were identical assuming a total build of over a thousand. The different RV's could also pose additional problems for any enemy ABM system."[265]

Delmar Crowson, Director of Military Application, agreed with Agnew. A few months after the Agnew letter, in a memo dated February 9, 1967, for the Chairman, Military Liaison Committee, Crowson wrote, "I believe that Dr. Agnew's suggestion has considerable merit. ...Three examples in the strategic missile warhead stockpile serve as cases in point: the recent ANA (Actuator, Nuclear Arming) failure in the MK 47Y2 warhead for POLARIS; the high-altitude failure of the arm-safe inspection port in the MK 58 warhead (MK 2 R/V) for POLARIS; and the ANA failure in the MK 56 warhead for MINUTEMAN. In each case it has been comforting to have alternate warheads in the stockpile..."[266] [Author's note: The three warheads cited by Crowson were all designed at Livermore.]

[265]H. M. Agnew to General Earle G. Wheeler, USA, W-1989 (SRD) (November 29, 1966), p. 1, B11, Drawer 56, Folder 1 of 4.

[266]Delmar L. Crowson, Memorandum for Chairman, Military Liaison Committee to the U. S. Atomic Energy Commission, Subject: "Concept of Mixed Warheads for Strategic Missiles," (SRD) (February 9, 1967), 2 pp., B11, Drawer 56, Folder 1 of 4.

4. Engineering Philosophy

Another argument, related somewhat to the "don't put all your eggs in one basket" argument, was the point that Agnew made about the differences in engineering philosophy between the two laboratories.

In a letter to Camm dated September 11, 1972, Agnew wrote, "One strength of this Laboratory has been its consistent ability to meet the actual needs of the military with realistic design concepts and practical engineering. In addition, we are very conscious of development and production costs and involve our weapon engineering people in the design from the start. This has been an important aspect of our ability to minimize costs and stay within budgets while at the same time delivering reliable hardware. We feel that our past experience with Mk 18 and ABC, together with our current Mk 400 efforts, will enable us to continue this for the Mk 400 warhead."[273]

In his letter to Camm on November 27, 1972, Agnew reported, "As we have made clear, there are differences in basic physics design philosophies and engineering approaches between the two laboratories." He indicated, "In particular, LASL design philosophy is to rely more on demonstrated fabrication techniques (often worked out and demonstrated at LASL), and simplicity in design wherever possible. We feel that our approach has led to significant differences between our warhead design and those of LLL. A mixture of LLL and LASL warheads definitely should improve the confidence in the strategic missile deterrent." Agnew also noted "The AEC has always supported the two laboratories to make certain that, through competition, different options would be available to them and to the DoD. Not to take advantage of these options is to ignore the basic rationale for supporting the opportunity to provide the options in the first place. In today's climate this point should receive very serious weighting in your deliberation."[274]

5. Cooperation

Agnew tried to make it clear that the LASL group was willing to cooperate to the fullest extent and to provide whatever the Military wanted.

On September 11, 1972, Agnew wrote Major General Camm, "It is important also to realize that we have worked actively with Lockheed and SSPO for the past two years on the Mk 400 and before that on the CAFE program and have a good working relationship with both... Stan Burriss, President of Lockheed, is very friendly to the LASL having been a senior member of LASL before joining Lockheed."[275]

[273]H. M. Agnew to Major General Frank A. Camm, DIR-2293 (SRD) (September 11, 1972), 3 pp., B11, Drawer 56, Folder 1 of 4.
[274]H. M. Agnew to Major General F. A. Camm, DIR-2296 (SRD) (November 27, 1972), 7 pp., B11, Drawer 56, Folder 1 of 4.
[275]H. M. Agnew to Major General Frank A. Camm, DIR-2293 (SRD) (September 11, 1972), 3 pp., B11, Drawer 56, Folder 1 of 4.

In his November 27, 1972, letter to Camm, Agnew implied that all the LASL team was eager to work with the Navy and the Navy's contractors and vice versa. Agnew stated, "In a nutshell, the Navy, Lockheed and the Air Force wish to work with us." Agnew also noted, "Industry and the DoD sense that they are missing an important design input and working relationship by not interacting directly with the LASL in the strategic offensive warhead area."[276]

6. Program Balance

Agnew felt that to remain a viable laboratory, each laboratory must work on all the different types of weapons going to the stockpile.

In a letter dated November 17, 1970, to Michael May at Livermore, Agnew stated, "...I believe it would not be a healthy condition for the country, the AEC, or the laboratories if the LASL were to concentrate on providing only tactical offensive warheads and bombs to the stockpile and LRL were to limit its endeavor to strategic offensive warheads." Agnew informed May, "...we are concentrating a sizeable portion of our advanced development technology on getting into a position to respond rapidly to the need for a new strategic offensive warhead whenever the AEC is called upon to provide one.

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In a letter dated August 10, 1972, Agnew noted that during the late 1950s time period it had been agreed that both the Los Alamos and Livermore laboratories should maintain competence in all areas of weapon design; each laboratory would not just specialize in one area of nuclear weapon technology. He stated, "At the same time, it was agreed by both laboratories and by DMA that both laboratories would maintain competence 'across the board' rather than have one laboratory specialize in other areas of nuclear weapon technology."[278]

In his November 27, 1972, letter Agnew noted, "To achieve proper balance, a design laboratory must receive design responsibility for weapons program (i.e., Phase 3 assignments) in all areas of nuclear weapons within a reasonable time period. Otherwise, capabilities can atrophy or disappear because of the feeling that 'We never get those jobs.' When this happens the advantages of two-laboratory competition in the nuclear weapon field will disappear."[279]

Agnew also reported that he expected the W74 effort to decline at the same time that the Mk 400 effort was projected to increase. Agnew noted, "Consequently we anticipate no staffing problems for the Mk 400 Program. We need the work."[280]

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[276] H. M. Agnew to Major General F. A. Camm, DIR-2296 (SRD) (November 27, 1972), 7 pp., B11, Drawer 56. Folder 1 of 4.

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[278] H. M. Agnew to Major General Frank A. Camm, DIR-2292 (SRD) (August 10, 1972), 7 pp., B11, Drawer 56, Folder 1 of 4.

[279] H. M. Agnew to Major General F. A. Camm, DIR-2296 (SRD) (November 27, 1972), 7 pp., B11, Drawer 56, Folder 1 of 4.

[280] H. M. Agnew to Major General F. A. Camm, DIR-2296 (SRD) (November 27, 1972), 7 pp., B11, Drawer 56, Folder 1 of 4.

7. Yield: The Confetti Argument

Agnew felt that the yield of the W68 was too low to be really effective. In addition, in terms of the overall total yield available from all the W68 warheads, the W68 design was very costly in terms of the amount of required special nuclear materials.

In an April 1972 TWX to Assistant Director for Safety and Liaison (Division of Military Application) Colonel Robert T. Duff, Agnew reported that he was worried about maintaining the U.S. nuclear deterrent. Agnew noted, "It occurs to me that as we go to lower and lower yields in our strategic missile warheads and the Soviet Union builds up a better and better civil defense position, the reality of this deterrent may become questionable.

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If the Soviet leadership believes this, then our strategic deterrent will have lost a good deal of its force. If our MIRV trend continues we'll be threatening to throw confetti at a potential aggressor. Confetti has high penetration and survivability but little deterrent power."[281]

In a letter dated October 10, 1972, to Giller, at that time Assistant General Manager for National Security, Agnew again noted several reasons why low yield warheads might not be the best solution for maximizing the deterrence capability of the stockpile. He reported that considering the number of required submarines and the low efficiency in their use of special nuclear material, the low-yield warheads were not very cost effective. Moreover, Agnew pointed out that for the Hiroshima device, the effects on Hiroshima in terms of loss of substantial buildings and the people in them "wasn't all that impressive." In terms of loss of life, the USSR had lost more than ten million people in WWII. Although the Soviets had an extensive civil-defense network in place, even if that did not work to reduce loss of civilian lives, the Soviets might not mind losing a few people. Agnew wrote, "Again, to me, to continue to increase warhead numbers at the cost of a decrease in yield per warhead could eventually lead to no deterrence in the minds of those we hope to deter." Agnew stated, "I feel very strongly that we should endeavor to convince the DoD that what they should have on the next round is a mix of yields.

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8. Capability

Agnew in his August 10, 1972, letter to Camm pointed out that the Los Alamos group had been developing suitable technology applicable to the new strategic missile warheads. He wrote, "In summary then, we have been working very hard to provide the very latest technology in warhead designs incorporating the most advanced minimum weight hardening techniques to provide an optimum warhead for the next round of strategic missile warheads. In fact, our work has been of such outstanding quality that we have been invited by Admiral Levering Smith to

[281] H. M. Agnew, University of California, Los Alamos Scientific Laboratory, Los Alamos, N.M. to BY3/Colonel Robert T. Duff, USAF, Assistant Director for Safety and Liaison, Division of Military Application USAEC, Wash., D.C. (SRD) (April 14, 1972), pp. 1–2, B11, Drawer 56, Folder 1 of 4.

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join his Steering Task Group for the FBM Weapon System Program in anticipation of our supplying TRIDENT with its warhead."[283]

Agnew felt that the LASL group had had extensive experience in the areas of vulnerability, hardening, and RV/warhead integration. Again, in a letter to Camm dated September 11, 1972, Agnew wrote, "Also, our in-house work and underground testing program in the vulnerability and hardening area have made a significant contribution to the nation's overall capability in this area." He also noted, "One unique advantage we have is that while we have a solid background of experience in reentry system design we are not tied to our past achievements and thereby inhibited in our approach to new designs."[284] In his November 27, 1972, letter to Camm, Agnew gave examples of how the LASL team had been the leader in several aspects of the vulnerability program.

(b)(3)

[redacted] This experience had been demonstrated in the successful Mk 18 and Mk 400 programs. With money very tight and the need to limit the expense of testing at NTS, the LASL team was in the best position to develop the Mk 400 warhead with a minimum number of tests. Agnew told Camm, "Once the Phase 3 has been awarded, we will design a package in which both the primary and secondary are so configured as to provide the best possible warhead to satisfy the specific DoD requirements."[286]

9. Promise of the Next Strategic Missile Warhead

In his August 10, 1972, letter to Camm in which Agnew discussed the history of previous weapon assignments, Agnew noted that at the time of the Mk 3/W68 warhead assignment to Livermore the Los Alamos group had been promised the development responsibility "for the next strategic missile warhead, whatever it might be…"[287]

In a letter dated September 11, 1972, to Camm, Agnew again reminded Camm that LASL had been told that they would receive development responsibility for the next strategic reentry system. To meet this obligation, the members of the LASL weapon groups had been developing and testing warheads for the Mk 19, Mk 18, ABC, and Mk 400 programs. This work had resulted in the Laboratory being very involved in these types of systems. (b)(3) [redacted] Agnew reported, "These two tests cover the spectrum of possible secondary designs for the Mk 400." Agnew also noted that the design of a suitable primary for the Mk 400 program was underway. He concluded his September 11 letter by stating "We feel

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[283]H. M. Agnew to Major General Frank A. Camm, DIR-2292 (SRD) (August 10, 1972), 7 pp., B11, Drawer 56, Folder 1 of 4

[284]H. M. Agnew to Major General Frank A. Camm, DIR-2293 (SRD) (September 11, 1972), 3 pp., B11, Drawer 56, Folder 1 of 4.

(b)(3)

[redacted]

[286]H. M. Agnew to Major General F. A. Camm, DIR-2296 (SRD) (November 27, 1972), 7 pp., B11, Drawer 56, Folder 1 of 4.

[287]H. M. Agnew to Major General Frank A. Camm, DIR-2292 (SRD) (August 10, 1972), p. 4, B11, Drawer 56, Folder 1 of 4.

that our past experience with Mk 18 and ABC, together with our current Mk 400 efforts, will enable us to continue this [successful effort] for the Mk 400 warhead."[288]

10. Morale

Agnew was fearful concerning the effect that an award of the Phase 3, Mk 400 warhead to Livermore might have on Los Alamos weapon personnel. Agnew in his November 27, 1972, letter to Camm noted, "After having had the vision to work in this field and having been extremely successful, not to receive this assignment would have a very severe impact on our staff morale."[289]

[288]H. M. Agnew to Major General Frank A. Camm, DIR-2293 (SRD) (September 11, 1972), 3 pp., B11, Drawer 56, Folder 1 of 4.

[289]H. M. Agnew to Major General F. A. Camm, DIR-2296 (SRD) (November 27, 1972), p. 7, B11, Drawer 56, Folder 1 of 4.

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